DICTIONARY

OF

CHEMISTRY, MINERALOGY, AND GEOLOGY.

ABSORB. A piece of sponge absorbs, or drinks up, water into its pores, and so does a snowball, or a piece of sugar. This term in chemistry, is more particularly applied to the action of withdrawing moisture from the atmosphere. This is effected by various substances, as by pure soda or potass, sulphuric acid, or quicklime. The soil of the earth absorbs water from the air, and the more finely divided it is, the greater is its power. There is also a great difference in the powers of the constituent parts of the soil. Vegetable substances have a greater energy than animal substances; animal substances a greater than compounds of alumina or silica; and compounds of alumina and silica greater than carbonates of lime and magnesia. The stiff clays which take up the greatest quantity of water, when it is poured upon them in a fluid form, are not the soils which absorb most moisture from the atmosphere in dry weather. They cake, and present only a small surface to the air; and the vegetation upon them is burnt up almost as readily as upon sands. The common air, or the gases, may be absorbed by water, dry charcoal, and other substances.

ABSORBENT. This is an epithet employed to express the property of bodies absorbing or withdrawing moisture, or gases, from the air. This is not confined to the strong acids, to dried potass, or soda, to alkaline earths, as strontian or quicklime, or to deliquescent salts, which are bodies which unite with water in every proportion, but it is possessed by other bodies, apparently inert and insoluble. In order to ascertain the absorbent power of any body, let it be heated and rendered thoroughly dry by the fire, then let it be put into a bottle furnished with a close glass stopper in order to cool, and be prevented from imbibing moisture from the atmosphere during the time it is cooling. Then put it into a large bottle and confine it, and a delicate hygrometer being introduced will shew the effect of the absorbent body in producing dryness on the surrounding air. The hygrometer employed in this experiment ought to be very delicate, and to be brought to the point of humidity before commencement.

It has been ascertained that the more a soil is pulverised by vegetation, or agricultural labour, the greater is its absorbent power: and the fertility of the soil without doubt must much depend on this faculty of imbibing moisture, as it thereby more readily affords to vegetables their proper supply, or the necessary pabulum, or food, for their support.

ABSORPTION, is the act of absorbing, and is said to take place in a variety of cases, such as are explained in the preceding articles, or when a liquid or solid absorbs a gaseous fluid. If muriatic acid gas be introduced into water, an absorption takes place, and the muriatic acid is the result. If ammoniacal gas and carbonic acid gas be brought into contact, there is an absorption of the one into the other, and solid carbonate of ammonia is the result.

Condensation is different from

absorption, being merely the effect of mechanical pressure, or the diminution of heat.

ABSTRACTION signifies, in common language, taking away; and it has the same meaning when applied to chemical operations. Thus when a body is rendered colder, there is said to be an abstraction of caloric. The verb *abstract* is in like manner employed in chemical language. Thus a body of a low temperature, brought in contact with a body of a higher temperature, is said to abstract parts of its caloric, by which its own temperature is increased. In the process of distillation, the volatile products which come over, and are condensed in the receivers, are said to be abstracted from the fixed parts which remain behind.

ACANTICONE. Vide EPIDOTE.

ACERATES. In the juice of the acer campestre there is supposed to be a peculiar acid, and also a portion of lime. From this juice is obtained a salt, which is called an accrate. It is white, semi-transparent, soluble in 100 parts of cold water, and 50 of hot water. It has not such a power of absorption as to be affected by exposure to the air.

ACERIC ACID. The acid supposed to be found in the juice of the maple. It may here be observed that modern chemists have, with little discretion, prodigiously multiplied the number of acids said to be found in the animal, vegetable, and mineral kingdoms; and that a sufficiently rigorous analysis has not, in many cases, been employed; neither has any very correct system been established for determining what circumstances are of sufficient importance to constitute a distinct acid from others formerly admitted.

ACESCENT is a term which signifies becoming sour, and is chiefly applied to such vegetable and animal juices as become sour of themselves. One of the most remarkable instances of bodies becoming acescent, is that of wine or beer, not only in casks, but even in corked bottles, during a thunder-storm. The manner in which this is effected has never been properly explained; but that it depends on electrical phenomena is obvious. In certain morbid states of the human stomach, matter contained in it becomes acescent with astonishing rapidity. To counteract this tendency, physicians prescribe bitters, antacids, and purgatives.

ACETATES. Salts composed of acetic acid and salifiable bases. They are all soluble in water.

ACETIC ACID. This is the same which, in a very diluted and impure state, is called vinegar. Of vinegar there are four sorts in use in commerce: 1. wine vinegar; 2. malt vinegar; 3. sugar vinegar; 4. wood vinegar. These will be noticed under the article VINEGAR. It is usually supposed that a vinous fermentation must, in all cases, precede the formation of vinegar; but, though it is usually so, there are exceptions: thus dough becomes sour, so does starch, and also cabbages, in the making of sour crout, without any such fermentation. This acid is obtained from many vegetables, and from animal substances, by distillation. In order to obtain it perfectly pure, for the purposes of chemical experiment, there are several modes. 1. Distil from a glass retort into a refrigerated receiver, four parts of acetate of lead, usually called sugar of lead, with one of sulphuric acid. 2. Mix gently calcined sulphate of iron with two and a half the quantity of sugar of lead, and distil from a porcelain retort. These are economical processes. 3. To obtain very strong acetic acid, distil two parts of fused acetate of potass, with one of the strongest sulphuric acid, from a glass retort, into a refrigerated receiver. A small portion of sulphurous acid, which contaminates it, may be removed by re-distillation from a little acetate of lead.

The OXY ACETIC acid is obtained by dissolving deutoxide of barium in acetic acid, and afterwards pouring in sulphuric acid, which will precipitate the barytes, and an oxygenized acid remains.

The acetic acid unites with all the alkalis and most of the earths, and with these bases it forms compounds, some of which are crystalizable, and others have not yet been

reduced to a regularity of figure. The salts it forms are distinguished by their great solubility; their decomposition by fire, which carbonizes them; the spontaneous alteration of their solution; and their decomposition by a great number of acids, which extricate from them the acetic acid in a concentrated state. It unites likewise with most of the metallic oxides.

With barytes the saline mass formed by the acetic acid does not crystallize; but, when evaporated to dryness, it deliquesces by exposure to air. This mass is not decomposed by acid of arsenic. By spontaneous evaporation, however, it will crystallize in fine transparent prismatic needles, of a bitterish acid taste, which do not deliquesce when exposed to the air, but rather effloresce.

With potash this acid unites, and forms a deliquescent salt, scarcely crystallizable, called formerly foliated earth of tartar, and regenerated tartar. The solution of this salt, even in closely stopped vessels, is spontaneously decomposed: it deposits a thick, mucous, flocculent sediment, at first gray, and at length black; till at the end of a few months nothing remains in the liquor but carbonate of potash, rendered impure by a little coaly oil.

With soda it forms a crystallizable salt, which does not deliquesce. This salt has very improperly been called mineral foliated earth. According to the new nomenclature it is acetate of soda.

The salt formed by dissolving chalk or other calcareous earth in distilled vinegar, formerly called salt of chalk, or fixed vegetable sal ammoniac, and by Bergman calx acetata, has a sharp bitter taste, appears in the form of crystals, resembling somewhat ears of corn, which remain dry when exposed to the air, unless the acid has been superabundant, in which case they deliquesce. By distilling without addition, the acid is separated from the earth, and appears in the form of a white, acid, and inflammable vapour, which smells like acetic ether, somewhat empyreumatic, and which condenses into a reddish brown liquor.

This liquor, being rectified, is very volatile and inflammable: upon adding water it acquires a milky appearance, and drops of oil seem to swim upon the surface. After this thick oil. When this earthy salt is mixed with a solution of sulphate of soda, and exposed to heat, a reddish brown liquor remains behind in the retort, and a black careous earth is precipitated along with the sulphuric acid; the acetic acid uniting with the soda, makes a crystallizable salt, by the calcination of which to whiteness, the soda may be obtained. This acetic calcareous salt is not soluble in spirit of wine.

Of the acetate of strontian little is known, but that it has a sweet taste, is very soluble, and is easily decomposed by a strong heat.

The salt formed by uniting vinegar with ammonia, called by the various names of spirit of Mindererus, liquid sal ammoniac, acetous sal ammoniac, and by Bergman alkali volatile acetatum, is generally in a liquid state, and is commonly believed not to be crystallizable, as in distillation it passes entirely over into the receiver. It nevertheless may be reduced into the form of small needle-shaped crystals, when this liquor is evaporated to the consistence of a syrup.

Westendorf, by adding his concentrated vinegar to carbonate of ammonia, obtained a pellucid liquid, which did not crystallize; and which by distillation was totally expelled from the retort, leaving only a white spot. In the receiver under the clear fluid a transparent saline mass appeared, which being separated from the fluid, and exposed to gentle warmth, melted and threw out abundance of white vapours, and in a few minutes shot into sharp crystals resembling those of nitre. These crystals remain unchanged while cold, but they melt at 120°, and evaporate at about 250°. Their taste at first is sharp and then sweet, and they possess the general properties of neutral salts.

With magnesia the acetic acid unites, and, after a perfect saturation, forms a viscid saline mass, like a solution of gum arabic, which

does not shoot into crystals, but remains deliquescent, has a taste sweetish at first, and afterwards bitter, and is soluble in spirit of wine. The acid of this saline mass may be separated by distillation without addition.

Glucine is readily dissolved by acetic acid. This solution, as Vauquelin informs us, does not crystallize; but is reduced by evaporation to a gummy substance, which slowly becomes dry and brittle, retaining a kind of ductility for a long time. It has a saccharine and pretty strongly astringent taste, in which that of vinegar however is distinguishable.

Yttria dissolves readily in acetic acid, and the solution yields by evaporation crystals of acetate of yttria. These have commonly the form of thick six sided plates, and are not altered by exposure to the air.

Alumine, obtained by boiling alum with alkali, and edulcorated by digesting in an alkaline lixivium, is dissolved by distilled vinegar in a very inconsiderable quantity. A considerable quantity of the earth of alum, precipitated by alkali, and edulcorated by hot water in Margraaf's manner, is soluble in vinegar, and a whitish saline mass is then obtained, which is not crystallizable. From this mass a concentrated acetic acid may be obtained by distillation. Or to a boiling solution of alum in water gradually add a solution of acetate of lead till no further precipitate ensues. The sulphate of lead having subsided, decant the supernatant liquor, evaporate, and the acetate of alum may be obtained in small needle-shaped crystals, having a strong styptic and acetous taste. This salt is of great use in dying and calico-printing. See ALUMINA.

Acetate of zircone may be formed by pouring acetic acid on newly precipitated zircone. It has an astringent taste. It does not crystallize; but, when evaporated to dryness, forms a powder, which does not attract moisture from the air. It is very soluble both in water and alcohol; and is not so easily decomposed by heat as nitrate of zircone.

The acetic acid has no action upon siliceous earth; for the needle-shaped crystals observed by Durande in a mixture of vinegar with the earth precipitated from a liquor of flints, do not prove the solubility of siliceous earth, as Leonhardi observes.

Concerning the action of vinegar on alcohol, see ETHER. This acid has no effect upon fat oils, except that when distilled together, some kind of mixture takes place: as the Abbé Rozier observes. Neither does distilled vinegar act upon essential oils; but Westendorf's concentrated acid dissolved about a sixth part of oil of rosemary, or one half its weight of camphor; which latter solution was inflammable: and the camphor was precipitated from it by adding water.

Vinegar dissolves the true gums, and partly the gum resins, by means of digestion.

Boerhaave observes, that vinegar by long boiling dissolves the flesh, cartilages, bones, and ligaments of animals.

ACIDS are of great importance in the science of chemistry, from their power of dissolving earths and metals, and from the many compounds which they form. Their properties may be stated to be:—

1. They are sour to the taste.
2. They combine with water in every proportion, and in doing so great heat is evolved, and the bulk of the two liquids is condensed.
3. They change purple vegetable colours to red.
4. They unite with metallic oxides, alkalis, and earths, and form salts.

The quantity of alkali which an acid will saturate is a good rule of estimating its power.

Many of the acids are formed by the union of oxygen with some other substance called a base; thus oxygen and sulphur form sulphuric acid. It was a favourite theory of Lavoisier that all acids were thus formed, and that their power depended upon the quantity of oxygen which they contained; but it has been found that this is not a good criterion. The muriatic acid has been found to contain no oxygen, and to consist merely of a substance called chlorine and hydrogen; the prussic acid consists of a base called cyanogen and hydrogen,

with no oxygen. In many others there is no oxygen. A substance, therefore, to be entitled to be called an acid, only requires to possess the properties already explained. The properties will be given under their different names.

ACIDIFIABLE signifies capable of being converted into an acid. The substances are sometimes termed *radicals* and acidifiable bases.

ACIDULE signifies a little acid, and is applied by the French to such salts as supertartrate of potass, which contain such an excess of acid as to manifest acid properties.

ACTINOLITE, a mineral, of which there are three varieties, the crystallized, the asbestous, and the glassy. The latter consists of:—

Silica	50·0
Lime	9·75
Magnesia	19·25
Oxide of iron	11·00
Alumina	0·75
Oxide of manganese	0·50
Oxide of chromium	3·00
Potass	0.50
Moisture	5·00
Loss	0·25
	100·00

ADAMANT is a word used instead of diamond; and, in some old authors, it is also employed instead of magnet.

ADAMANTINE SPAR. This stone, which comes to us from the peninsula of Hither India, and also from China, has not engaged the attention of the chemical world till within a few years past. It is remarkable for its extreme hardness, which approaches to that of the diamond, and by virtue of which property it is used for polishing gems.

Two varieties of this stone are known in Europe. The first comes from China. It is crystallized in six-sided prisms, without pyramids, the length of which varies from half an inch to an inch, and their thickness is about three quarters of an inch. Its colour is gray of different shades. The larger pieces are opaque; but thin pieces and the edges of the prisms are transparent. Its fracture is brilliant, and its texture spathose; which causes its surface to appear lightly striated. Its crystals are covered with a very fine and strongly adherent crust of plates of silvery mica, mixed with particles of red fel-spar. A yellow superficial covering of sulphate of iron was observed upon one specimen.

This stone is so hard that it not only cuts glass as easily as a diamond, but likewise marks rock crystal and several other hard stones. Its specific gravity is 3.710.

Small crystalline grains of magnetical ferruginous calx are occasionally found in the adamantine spar of China, which may be separated by the magnet when the stone is pulverized.

The second variety, which comes from India, is called corundum by the inhabitants of Bombay. It differs from the former by a white colour, a texture more evidently spathose, and lastly, because the grains of magnetical iron are smaller than in the former specimens, and are not interspersed through its substance, but only at its surface.

From its hardness it is extremely difficult to analyze. M. Chenevix, by repeatedly heating it red hot, and then plunging it into cold water, caused it to appear fissured in every direction. He then put it into a steel mortar, about three quarters of an inch in diameter, and three inches deep, to which a steel pestle was closely fitted. A few blows on the pestle caused it to crumble, and the fragments were then easily reduced to an impalpable powder by an agate pestle and mortar. This powder was fused in a crucible of platinum with twice its weight of calcined borax, and the glass was dissolved by boiling in muriatic acid about twelve hours. The precipitates from this solution being examined, a specimen from China was found to give from 100 parts, 86.50 of alumina, 5.25 of silex, 6.50 of iron: one from Ava, alumina 87, silex 6.5, iron 4.5: one from Malabar, alumina 86.5, silex 7, iron 4: one from the Carnatic, alumina 91, silex 5, iron 1.5.

The Rev. Mr. W. Gregor analyzed a specimen from Thibet, in the collection of Mr. Rashleigh,

..., gave him alumina 81.75, silex ..125, oxide of titanium 4, water 0.937, but no iron.

This stone has been said to have been found in different parts of Europe, and near Philadelphia, in America; but most, if not all, of the specimens have proved not to be the adamantine spar. Lately, however, Prof. Pini has discovered a stone in Italy, the characters of which, as given by him, agree with those of the admantine spar.

ADHESION, or COHESION, is the power by which the particles of bodies are held together. Without such a power, all bodies would fall to pieces, and resolve themselves into the primary atoms of which they are composed. The diminution of temperature causes the particles of bodies to adhere more firmly together, and the increase of temperature makes them more easily separated: thus water below a certain temperature, or 32°, is solid; above that temperature, is fluid; and, if heated to 212°, is converted gradually into steam. The absolute force of cohesion in solids, is estimated by the weight necessary to pull them asunder. The cohesive power of metals is much increased by wire drawing, rolling, and hammering them. Mr. Rennie made a number of experiments, in order to ascertain the strength or cohesion of a variety of bodies employed in the various arts of life. His mode of doing this was to determine what weight was necessary in order to crush a cubical inch of these different bodies. The result of his experiments was as follows:

	lbs.av.
Elm	1284
American pine	1606
White deal	1928
English oak	3860
Ditto of five inches long, slipped with	2572
Ditto of four inches, ditto	5147
A prism of Portland stone, two inches long	805
Ditto statuary marble	3216
Craigleith stone	8688

Cubes of 1½ inch.

	Sp. gr.	lb.av.
Chalk	—	1127
Brick of a pale red colour	2.085	1265
Roe-stone, Gloucestershire	—	1449
Red brick, mean of two trials	2.168	1817
Yellow face baked Hammersmith paviors, 3 times	—	2254
Burnt ditto, mean of two trials	—	3243
Stourbridge, or fine brick	—	3864
Derby grit, a red friable sand-stone	2.316	7070
Derby grit from another quarry	2.428	9776
Killaly white free-stone not stratified	2.423	10264
Portland	2.428	10284
Craigleith, white free-stone	2.452	12346
Yorkshire paving, with the strata	2.507	12856
Ditto, against the strata	2.507	12856
White statuary marble, not veined	2.760	13632
Bramley-Fall sandstone, near Leeds, with strata	2.506	13632
Ditto, against strata	2.506	13632
Cornish granite	2.662	14302
Dundee sandstone, or breccia, two kinds	2.530	14918
A two inch cube of Portland	2.423	14918
Craigleith, with strata	2.452	15560
Devonshire red marble, variegated	—	16712
Compact limestone	2.584	17354
Peterhead granite, hard close-grained	—	18636
Black compact limestone, Limerick	2.598	19924
Purbeck	2.599	20610
Black Brabant marble	2.697	20742
Very hard free-stone	2.528	21254
White Italian veined marble	2.726	21783
Aberdeen granite, blue kind	2.625	24556

Cubes of different metals of ¼th inch were crushed by the following weights:

Cast iron	9773
Cast copper	7318
Fine yellow brass	10304
Wrought copper	6440
Cast tin	966
Cast lead	483

Bars of different metals, six inches

long, and a quarter of an inch square, were suspended by nippers, and broken by the following weights:

	lb.av.
Cast iron, horizontal . . .	1166
Ditto, vertical	1218
Cast steel, previously tilted .	8391
Blistered steel, reduced by the hammar	8322
Shear steel ditto	7977
Swedish iron ditto	4504
English iron ditto	3492
Hard gun metal, mean of two trials	2273
Wrought copper, reduced by hammer	2112
Cast copper	1192
Fine yellow brass . . .	1123
Cast tin	296
Cast lead	114

It deserves to be kept in mind that there is a considerable difference of cohesion in different portions of substances bearing the same name; and that accordingly whilst the above, or any other similar table, affords a general idea, it cannot be rigorously applied in all cases. In regard of Swedish and English iron in particular, the results of experiments performed with very great care have differed from those of Mr. Rennie. Thus Mr. Rennie gives

English iron - -	348.38
Swedish iron - -	449.34

But Count Sicklengen gives as follows:

English iron - -	348.38
Swedish iron - -	549.25

which is a very great difference.

In ropes, composed of vegetable or animal substances, there will be a still greater diversity of result in different trials.

According to Count Sicklengen the relative tenacity or cohesive power of the following metals is

Gold - -	150.935
Silver - -	190.771
Platina -	262.361
Copper -	304.696
Soft iron -	362.929
Hard iron - .	559.880

Of the CAUSE of the adhesion of bodies we are unable to give any certain account. Most writers have ascribed it to some innate affection of matter. This opinion is combated by Sir Richard Phillips, who ascribes it to the forms of the atoms concerned.

ADHESIVE SLATE. Vide CLAY.

ADIPOCERE. The attention of chemists has been much excited by the spontaneous conversion of animal matter into a substance considerably resembling spermaceti. The fact has long been well known, and is said to have been mentioned in the works of Lord Bacon. On the occasion of the removal of a very great number of human bodies from the ancient burying-place des Innocens at Paris, facts of this nature were observed in the most striking manner. Fourcroy may be called the scientific discoverer of this peculiar matter, as well as the saponaceous ammoniacal substance contained in bodies abandoned to spontaneous destruction in large masses. This chemist read a memoir on the subject in the year 1789 to the Royal Academy of Sciences, from which I shall abstract the general contents.

At the time of clearing the before mentioned burying-place, certain philosophers were specially charged to direct the precautions requisite for securing the health of the workmen. A new and singular object of research presented itself, which had been necessarily unknown to preceding chemists. It was impossible to foretel what might be the contents of a soil overloaded for successive ages with bodies resigned to the putrefactive process. This spot differed from common burying grounds, where each individual object is surrounded by a portion of the soil. It was the burying-ground of a large district, wherein successive generations of the inhabitants had been deposited for upwards of three centuries. It could not be foreseen that the entire decomposition might be retarded for more than forty years; neither was there any reason to suspect that any remarkable difference would arise from the singularity of situation.

The remains of the human bodies immersed in this mass of putrescence were found in three different states, according to the time they had been buried, the place they oc-

cupied, and their relative situations with regard to each other. The most ancient were simply portions of bones, irregularly dispersed in the soil, which had been frequently disturbed. A second state, in certain bodies which had always been insulated, exhibited the skin, the muscles, tendons, and aponeuroses, dry, brittle, hard, more or less gray, and similar to what are called mummies in certain caverns where this change has been observed, as in the catacombs at Rome, and the vault of the Cordeliers at Toulouse.

The third and most singular state of these soft parts was observed in the bodies which filled the common graves or repositories. By this appellation are understood cavities of thirty feet in depth and twenty on each side, which were dug in the burying-ground of the Innocents, and were appropriated to contain the bodies of the poor; which were placed in very close rows, each in its proper wooden bier. The necessity for disposing a great number obliged the men charged with this employment to arrange them so near each other, that these cavities might be considered, when filled, as an entire mass of human bodies, separated only by two planks of about half an inch thick. Each cavity contained between one thousand and fifteen hundred. When one common grave of this magnitude was filled, a covering of about one foot deep of earth was laid upon it, and another excavation of the same sort was made at some distance. Each grave remained open about three years, which was the time required to fill it. According to the urgency of circumstances, the graves were again made on the same spot, after an interval of time not less than fifteen years, nor more than thirty. Experience had taught the workmen, that this time was not sufficient for the entire destruction of the bodies, and had shewn them the progressive changes which form the object of Mr. Fourcroy's memoir.

The first of these large graves opened in the presence of this chemist, had been closed for fifteen years. The coffins were in good preservation, but a little settled, and the wood (probably deal) had a yellow tinge. When the covers of several were taken off, the bodies were observed at the bottom, leaving a considerable distance between their surface and the cover, and flattened as if they had suffered a strong compression. The linen which had covered them was slightly adherent to the bodies; and, with the form of the different regions, exhibited, on removing the linen, nothing but irregular masses of a soft ductile matter of a gray white colour. These masses environed the bones on all sides, which had no solidity, but broke by any sudden pressure. The appearance of this matter, its obvious composition and its softness, resembled common white cheese; and the resemblance was more striking from the print which the threads of the linen had made upon its surface. This white substance yielded to the touch, and became soft when rubbed for a time between the fingers.

No very offensive smell was emitted from these bodies. The novelty and singularity of the spectacle, and the example of the grave-diggers, dispelled every idea either of disgust or apprehension. These men asserted that they never found this matter, by them called *gras* (fat), in bodies interred alone; but that the accumulated bodies of the common graves only were subject to this change. On a very attentive examination of a number of bodies passed to this state, Mr. Fourcroy remarked, that the conversion appeared in different stages of advancement, so that, in various bodies, the fibrous texture and colour, more or less red, were discernible within the fatty matter; that the masses covering the bones were entirely of the same nature, offering indistinctly in all the regions a gray substance, for the most part soft and ductile, sometimes dry, always easy to be separated in porous fragments, penetrated with cavities, and no longer exhibiting any traces of membranes, muscles, tendons, vessels, or nerves. On the first inspection of these white masses, it might have been concluded that they were simply the cellular tissue, the compart-

ments and vesicles of which they very well represented.

By examining this substance in the different regions of the body, it was found that the skin is particularly disposed to this remarkable alteration. It was afterwards perceived that the ligaments and tendons no longer existed, or at least had lost their tenacity: so that the bones were entirely unsupported, and left to the action of their own weight. Whence their relative places were preserved in a certain degree by mere juxtaposition: the least effort being sufficient to separate them. The grave diggers availed themselves of this circumstance in the removal of the bodies, for they rolled them up from head to feet, and by that means separated from each other the extremities of the bones, which had formerly been articulated. In all these bodies which were changed into the fatty matter, the abdominal cavity had disappeared. The teguments and muscles of this region being converted into the white matter, like the other soft parts, had subsided upon the vertebral column, and were so flattened as to leave no place for the viscera, and accordingly there was scarcely ever any trace observed in the almost obliterated cavity. This observation was for a long time matter of astonishment to the investigators. In vain did they seek in the greater number of bodies the place and substance of the stomach, the intestines, the bladder, and even the liver, the spleen, the kidneys, and the matrix in females. All these viscera were confounded together, and for the most part no traces of them were left. Sometimes only certain irregular masses were found of the same nature as the white matter, of different bulks, from that of a nut to two or three inches in diameter, in the regions of the liver or of the spleen.

The thorax likewise offered an assemblage of facts no less singular and interesting. The external part of this cavity was flattened and compressed like the rest of the organs; the ribs, spontaneously luxated in their articulations with the vertebræ, were settled upon the dorsal column; their arched part left only a small space on each side between them and the vertebræ. The pleura, the mediastines, the large vessels, the aspera arteria, and even the lungs and the heart, were no longer distinguishable; but for the most part had entirely disappeared, and in their place nothing was seen but some parcels of the fatty substance. In this case, the matter which was the product of decomposition of the viscera, charged with blood and various humours, differs from that of the surface of the body, and the long bones, in the red or brown colour possessed by the former. Sometimes the observers found in the thorax a mass irregularly rounded, of the same nature as the latter, which appeared to them to have arisen from the fat and fibrous substance of the heart. They supposed that this mass, not constantly found in all the subjects, owed its existence to a superabundance of fat in this viscus, where it was found. For the general observation presented itself, that in similar circumstances, the fat parts undergo this conversion more evidently than the others, and afford a larger quantity of the white matter.

The external region in females exhibited the glandular and adipose mass of the breasts converted into the fatty matter very white and very homogeneous.

The head was, as has already been remarked, environed with the fatty matter; the face was no longer distinguishable in the greatest number of subjects; the mouth disorganized exhibited neither tongue nor palate; and the jaws, luxated and more or less displaced, were environed with irregular layers of the white matter. Some pieces of the same matter usually occupied the place of the parts situated in the mouth: the cartilages of the nose participated in the general alteration of the skin; the orbits instead of eyes contained white masses; the ears were equally disorganized; and the hairy scalp having undergone a similar alteration to that of the other organs still retained the hair. M. Four

croy remarks incidentally, that the hair appears to resist every alteration much longer than any other part of the body. The cranium constantly contained the brain contracted in bulk; blackish at the surface, and absolutely changed like the other organs. In a great number of subjects which were examined, this viscus was never found wanting, and it was always in the above-mentioned state; which proves that the substance of the brain is greatly disposed to be converted into the fat matter.

Such was the state of the bodies found in the burial-ground des Innocens. Its modifications were also various. Its consistence in bodies lately changed, that is to say, from three to five years, was soft and very ductile; containing a great quantity of water. In other subjects converted into this matter for a long time, such as those which occupied the cavities which had been closed thirty or forty years, this matter is drier, more brittle, and in denser flakes. In several which were deposited in dry earth, various portions of the fatty matter had become semi-transparent. The aspect, the granulated texture, and brittleness of this dried matter, bore a considerable resemblance to wax.

The period of the formation of this substance had likewise an influence on its properties. In general, all that which had been formed for a long time was white, uniform, and contained no foreign substance, or fibrous remains; such, in particular, was that afforded by the skin of the extremities. On the contrary, in bodies recently changed, the fatty matter was neither so uniform nor so pure as in the former; but it was still found to contain portions of muscles, tendons, and ligaments, the texture of which, though already altered and changed in its colour, was still distinguishable. Accordingly, as the conversion was more or less advanced, these fibrous remains were more or less penetrated with the fatty matter, interposed as it were betwen the interstices of the fibres. This observation shews, that it is not merely the fat which is thus changed, as was natural enough to think at first sight. Other facts confirm this assertion. The skin, as has been remarked, becomes easily converted into very pure white matter, as does likewise the brain, neither of which has been considered by anatomists to be fat. It is true, nevertheless, that the unctuous parts, and bodies charged with fat, appear more easily and speedily to pass to the state under consideration. This was seen in the marrow, which occupied the cavities of the longer bones. And again, it is not to be supposed, but that the greater part of these bodies had been emaciated by the illness which terminated their lives; notwithstanding which, they were all absolutely turned into this fatty substance.

An experiment made by M. Poulletier de la Salle, and Fourcroy likewise, evinced that a conversion does not take place in the fat alone. M. Poulletier had suspended in his laboratory a small piece of the human liver, to observe what would arise to it by the contact of the air. It partly putrefied, without, however, emitting any very noisome smell. Larvæ of the dermestes and bruchus attacked and penetrated it in various directions; at last it became dry, and after more than ten years' suspension, it was converted into a white friable substance resembling dried agaric, which might have been taken for an earthy substance. In this state it had no perceptible smell. M. Poulletier was desirous of knowing the state of this animal matter, and experiment soon convinced him and M. F. that it was very far from being in the state of an earth. It melted by heat, and exhaled in the form of vapour, which had the smell of a very fetid fat; spirit of wine separated a concrescible oil, which appeared to possess all the properties of spermaceti. Each of the three alkalis converted it into soap, and in a word it exhibited all the properties of the fatty matter of the burial-ground of the Innocents exposed for several months, to the air. Here then was a glandular organ, which in the midst of the atmosphere had undergone a change similar to that

of the bodies in the burying-place; and this fact sufficiently shews, that an animal substance which is very far from being of the nature of grease, may be totally converted into this fatty substance.

Among the modifications of this remarkable substance in the burying-ground before mentioned, it was observed that the dry, friable, and brittle matter, was most commonly found near the surface of the earth, and the soft ductile matter at a greater depth. M. Fourcroy remarks, that this dry matter did not differ from the other merely in containg less water, but likewise by the volatilization of one of its principles.

The grave-diggers assert, that near three years are required to convert a body into this fatty substance. But Dr. Gibbes, of Oxford, found, that lean beef secured in a running stream was converted into this fatty matter at the end of a month. He judges from facts, that running water is most favourable to this process. He took three lean pieces of mutton, and poured on each a quantity of the three common mineral acids. At the end of three days, each was much changed: that in the nitric acid was very soft, and converted into the fatty matter; that in the muriatic acid was not in that time so much altered; the sulphuric acid had turned the other black. M. Lavoisier thinks that this process may hereafter prove of great use in society. It is not easy to point out what animal substance, or what situation, might be the best adapted for an undertaking of this kind. M. L. points out fecal matters; but I have not heard of any conversion having taken place in these animal remains similar to that of the foregoing.

The result of M. Fourcroy's inquiries into the ordinary changes of bodies recently deposited in the earth, was not very extensive. The grave-diggers informed him, that these bodies interred do not perceptibly change colour for the first seven or eight days; that the putrid process disengages elastic fluid, which inflates the abdomen, and at length bursts it; that this event instantly causes vertigo, faintness, and nausea in such persons as unfortunately are within a certain distance of the scene where it takes place; but that when the object of its action is nearer, a sudden privation of sense, and frequently death, is the consequence. These men are taught by experience, that no immediate danger is to be feared from the disgusting business they are engaged in, excepting at this period, which they regard with the utmost terror. They resisted every inducement and persuasion which these philosophers made use of, to prevail on them to assist their researches into the nature of this active and pernicious vapour. M. Fourcroy takes occasion from these facts, as well as from the pallid and unwholesome appearance of the grave-diggers, to reprobate burials in great towns or their vicinity.

Such bodies as are interred alone, in the midst of a great quantity of humid earth, are totally destroyed by passing through the successive degrees of the ordinary putrefaction; and this destruction is more speedy, the warmer the temperature. But if these insulated bodies be dry and emaciated; if the place of deposition be likewise dry, and the locality and other circumstances such, that the earth, so far from receiving moisture from the atmosphere, becomes still more effectually parched by the solar rays; the animal juices are volatilized and absorbed, the solids contract and harden, and a peculiar species of mummy is produced. But every circumstance is very different in the common burying-grounds. Heaped together almost in contact, the influence of external bodies affects them scarcely at all, and they become abandoned to a peculiar disorganization, which destroys their texture, and produces the new and most permanent state of combination here described. From various observations which I do not here extract, it was found, that this fatty matter was capable of enduring in these burying-places for thirty or forty years, and is at length corroded and carried off by the aqueous putrid humidity which there abounds.

Among other interesting facts afforded by the chemical examination of this substance, are the following from experiments by M. Fourcroy.

1. This substance is fused at a less degree of heat than that of boiling water, and may be purified by pressure through a cloth, which disengages a portion of fibrous and bony matter. 2. The process of destructive distillation by a very graduated heat was begun, but not completed on account of its tediousness, and the little promise of advantage it afforded. The products which came over were water charged with volatile alkali, a fat oil, concrete volatile alkali, and no elastic fluid during the time the operation was continued. 3. Fragments of the fatty matter exposed to the air during the hot and dry summer of 1786 became dry, brittle, and almost pulverulent at the surface. On a careful examination, certain portions were observed to be semi-transparent, and more brittle than the rest. These possessed all the apparent properties of wax, and did not afford volatile alkali by distillation. 4. With water this fatty matter exhibited all the appearances of soap, and afforded a strong lather. The dried substance did not form the saponaceous combination with the same facility or perfection as that which was recent. About two thirds of this dried matter separated from the water by cooling, and proved to be the semi transparent substance resembling wax. This was taken from the surface of the soapy liquor, which being then passed through the filter, left a white soft shining matter, which was fusible and combustible. 5. Attempts were made to ascertain the quantity of volatile alkali in this substance by the application of lime, and of the fixed alkalis, but without success: for it was difficult to collect and appreciate the first portions which escaped, and likewise to disengage the last portions. The caustic volatile alkali, with the assistance of a gentle heat, dissolved the fatty matter, and the solution became perfectly clear and transparent at the boiling temperature of the mixture, which was at 185° F. 6. Sulphuric acid, of the specific gravity of 2·0, was poured upon six times its weight of the fatty matter, and mixed by agitation. Heat was produced, and a gas or effluvium of the most insupportable putrescence was emitted, which infected the air of an extensive laboratory for several days. M. Fourcroy says, that the smell cannot be described, but that it is one of the most horrid and repulsive that can be imagined. It did not, however, produce any indisposition either in himself or his assistants. By dilution with water, and the ordinary processes of evaporation and cooling, properly repeated, the sulphates of ammonia and of lime were obtained. A substance was separated from the liquor, which appeared to be the waxy matter, somewhat altered by the action of the acid. 7. The nitrous and muriatic acids were also applied, and afforded phenomena worthy of remark, but which for the sake of conciseness are here omitted. 8. Alcohol does not act on this matter at the ordinary temperature of the air. But by boiling it dissolves one-third of its own weight, which is almost totally separable by cooling as low as 55°. The alcohol, after this process, affords by evaporation a portion of that waxy matter which is separable by acids, and is therefore the only portion soluble in cold alcohol. The quantity of fatty matter operated on, was four ounces, or 2304 grains, of which the boiling spirit took up the whole except 26 grains, which proved to be a mixture of 20 grains of ammoniacal soap, and six or eight grains of the phosphates of soda and of lime. From this experiment, which was three times repeated with similar results, it appears that alcohol is well suited to afford an analysis of the fatty matter. It does not dissolve the neutral salts; when cold it dissolves that portion of concrete animal oil from which the volatile alkali had flown off, and when heated it dissolves the whole of the truly saponaceous matter, which is afterwards completely separated by cooling. And accordingly it was

found, that a thin plate of the fatty matter, which had lost nearly the whole of its volatile alkali, by exposure to the air for three years, was almost totally dissolved by the cold alcohol.

The concrete oily or waxy substance obtained in these experiments constitutes the leading object of research, as being the peculiar substance with which the other well known matters are combined. It separates spontaneously by the action of the air, as well as by that of acids. These last separate it in a state of greater purity, the less disposed the acid may be to operate in the way of combustion. It is requisite, therefore, for this purpose, that the fatty matter should be previously diffused in 12 times its weight of hot water; and the muriatic or acetous acid is preferable to the sulphuric or the nitrous. The colour of the waxy matter is grayish; and though exposure to the air, and also the action of the oxygenated muriatic acid did produce an apparent whiteness, it nevertheless disappeared by subsequent fusion. No method was discovered by which it could be permanently bleached.

The nature of this wax or fat is different from that of any other known substance of the like kind. When slowly cooled after fusion, its texture appears crystalline or shivery, like spermaceti; but a speedy cooling gives it a semi transparency resembling wax. Upon the whole, nevertheless, it seems to approach more nearly to the former than to the latter of these bodies. It has less smell than spermaceti, and melts at 127° F.; Dr. Bostock says 92°. Spermaceti requires 6° more of heat to fuse it, (according to Dr. Bostock 20°). The spermaceti did not so speedily become brittle by cooling as the adipocere. One ounce of alcohol of the strength between 39 and 40 degrees of Baumé's areometer, dissolved when boiling hot, 12 gros of this substance, but the same quantity in like circumstances dissolved only 30 or 36 grains of spermaceti. The separation of these matters was also remarkably different, the spermaceti being more speedily deposited, and in a much more regular and crystalline form. Ammonia dissolves with singular facility, and even in the cold, this concrete oil separated from the fatty matter; and by heat it forms a transparent solution, which is a true soap. But no excess of ammonia can produce such an effect with spermaceti.

M. Fourcroy concludes his memoir with some speculations on the change to which animal substances in peculiar circumstances are subject. In the modern chemistry, soft animal matters are considered as a composition of the oxides of hydrogen and the carbonated azote, more complicated than those of vegetable matters, and therefore more incessantly tending to alteration. If then the carbon be conceived to unite with the oxygen, either of the water which is present, or of the other animal matters, and thus escape in large quantities in the form of carbonic acid gas, we shall perceive the reason why this conversion is attended with so great a loss of weight, namely, about nine-tenths of the whole. The azote, a principle so abundant in animal matters, will form ammonia by combining with the hydrogen; part of this will escape in the vaporous form, and the rest will remain fixed in the fatty matter. The residue of the animal matters deprived of a great part of their carbon, of their oxygen, and the whole of their azote, will consist of a much greater proportion of hydrogen, together with carbon and a minute quantity of oxygen. This, according to the theory of M. Fourcroy, constitutes the waxy matter, or adipocere, which in combination with ammonia forms the animal soap, into which the dead bodies are thus converted.

Muscular fibre macerated in dilute nitric acid, and afterwards well washed in warm water, affords pure adipocere, of a light yellow colour, nearly of the consistence of tallow, of a homogeneous texture, and of course free from ammonia. This is the mode in which it is now commonly procured for chemical experiment.

Ambergris appears to contain adipocere in large quantity, rather more than half of it being of this substance.

ADIT, derived from a Latin word signifying an approach, is employed in mining to subterraneous passages, slightly inclined, begun at the bottom of a neighbouring valley, and continued up to the vein for the purpose of carrying out the minerals, and drawing off the water. If the mine require draining, by means of a steam engine, it will be sufficient to raise the water to the level of the adit. The dimensions of an adit are usually six feet high and three wide, being sufficient to allow two persons to pass.

ADOPTER, a vessel with two necks placed between a retort and a receiver, and serving to increase the length of the neck of the former.

ADULARIA. Vide FELSPAR.

AERATED ALKALINE WATER, water impregnated with an alkaline and carbonic acid gas.

AERIAL ACID, is another name for carbonic acid gas, which see.

AEROLITES, OR METEORIC STONES, are compounds of earthy and mineral substances, which have at different times fallen from the atmosphere to the earth. Numerous instances were recorded in Livy and Pliny, as well as in other ancient authors, and many instances were recorded in later writers, and from time to time accounts were given to the world of stones having been seen to descend from the air; but such was the incredulity of those who affected to be wiser than the rest of mankind, that these numerous and well authenticated events were attributed to the influence of deception and vulgar superstition. At last, however, philosophical scepticism was compelled to give way, and this was, in no small degree, owing to the valuable labours of an English cultivator of science.

In the 13th volume of Tilloch's Magazine is an important chronological list of meteoric stones.

Sect. I.—*Before the Christian Era.*

Division I.—Containing those which can be referred pretty nearly to a date.

A. C.

1478. The thunderstone in Crete, mentioned by Malchus, and regarded probably as the symbol of Cybele.—*Chronicle of Paros*, l. 18, 19.

1451. Shower of stones which destroyed the enemies of Joshua at Beth-horon.—*Joshua*, chap. x. 11.

1200. Stones preserved at Orchomenos.—*Pausanias.*

1168. A mass of iron upon Mount Ida in Crete.—*Chronicle of Paros*, l. 22.

705 or 704. The *Ancyle* or sacred shield, which fell in the reign of Numa. It had nearly the same shape as those which fell at the Cape and at Agram.—*Plutarch, in Num.*

654. Stones which fell upon Mount Alba, in the reign of Tullus Hostilius.—"*Crebri cecidere cœlo lapides.*"—*Liv.* l. 31.

644. Five stones which fell in China, in the country of Song.—*De Guignes.*

466. A large stone at Ægospotamos, which Anaxagoras supposed to come from the sun. It was as large as a cart, and of a burnt colour.—"*Qui lapis etiam nunc ostenditur, magnitudine vehis, colore adusto.*"—*Plutarch, Pliny*, lib. ii. cap. 58.

465. A stone near Thebes.—*Scholiast of Pindar.*

461. A stone fell in the Marsh of Ancona.—*Valerius Maximus, Liv.* lib. vii. cap. 28.

343. A shower of stones fell near Rome.—*Jul. Obsequens.*

211. Stones fell in China, along with a falling star.—*De Guignes*, &c.

205 or 206. Fiery stones.—*Plutarch, Fab. Max.* cap. 2.

192. Stone fell in China.—*De Guignes.*

176. A stone fell in the Lake of Mars.—"*Lapidem in Agro Crustumino in Lacum Martis de cœlo cecidisse.*"—*Liv.* xli. 3.

90 or 80. "*Eodem causam dicunt, lateribus coctis pluisse, in ejus anni acta relatum est.*"—*Plin. Nat. Hist.* lib. ii. cap 56.

89. Two large stones fell at Yong in China. The sound was heard over 40 leagues.—*De Guignes.*

56 or 52. Spongy iron fell in Lucania.—*Plin.*
46. Stones fell at Acilla.—*Cæsar.*
38. Six Stones fell in Leang in China.—*De Guignes.*
29. Four stones fell at Po in China. —*De Guignes.*
22. Eight stones fell from heaven, in China.—*De Guignes.*
12. A stone fell at Ton-Kouan.—*De Guignes.*
9. Two stones fell in China.—*De Guignes.*
6. Sixteen stones fell in Ning-Tcheon, and other two in the same year.—*De Guignes.*

Division II.—Containing those of which the date cannot be determined.

The mother of the Gods which fell at Pessinus.
The stone preserved at Abydos.—*Plin.*
The stone preserved at Cassandria. —*Plin.*
The Black stone, and also another preserved in the Caaba of Mecca.
The "Thunderbolt, black in appearance like a hard rock, brilliant and sparkling," of which the blacksmith forged the sword of Antar.—See *Quarterly Review*, vol. xxi. p. 225. and *Antar*, translated by T. Hamilton, Esq. p. 152.
Perhaps the stone preserved in the coronation chair of the kings of England.

Sect. 2.—After the Christian Era.

P. C.
A stone in the country of the Vocontini.—*Plin.*
452. Three large stones fell in Thrace.—*Cedrenus and Marcellini, Chronicon*, p. 29.—"*Hoc tempore*," says Marcellinus, "*tres magni lapides e cœlo in Thracia ceciderunt.*"
Sixth Century. Stones fell upon Mount Lebanon, and near Emisa in Syria.—*Damascus.*
About 570. Stones near Bender in Arabia.—*Alkoran*, vi. 16. and cv. 3. and 4.
616. A fiery stone at Constantinople.—*Several Chronicles.*
823. A shower of pebbles in Saxony.
852. A stone fell in Tabaristan, in July or August.—*De Sacy and Quatremere.*
897. A stone fell at Ahmedabad.—*Quatremere.* In 892, according to the *Chron. Syr.*
951. A stone fell near Augsburg. —*Alb. Stad.* and others.
998. Two stones fell, one near the Elbe, and the other in the town of Magdeburg.—*Cosmas and Spangenberg.*
1009. A mass of iron fell in Djordjan.—*Avicenna.*
1021. Stones fell in Africa between the 24th of July and the 21st of August.—*De Sacy.*
1112. Stones or iron fell near Aquileja.—*Valvasor.*
1135 or 1136. A stone fell at Oldisleben, in Thuringia.—*Spangenberg*, and others.
1164. During Pentecost, iron fell in Misnia.—*Fabricius.*
1198. A stone fell near Paris.
1249. Stones fell at Quedlinbourg, Ballenstadt and Blankenburg, on the 26th July.—*Spangenberg* and *Rivander.*
Thirteenth Century. A stone fell at Wurzburg.—*Schottus, Phys. Cur.*
Between 1251 and 1363. Stones fell at Welixoi-Ussing in Russia. —*Gilbert's Annal.* tom. 35.
1280. A stone fell at Alexandria in Egypt.—*De Sacy.*
1304, Oct. 1. Stones fell at Friedland or Friedberg.—*Kranz* and *Spangenberg.*
1305. Stones fell in the country of the Vandals.
1328, Jan. 9. In Mortahiah and Dakhaliah.—*Quatremere.*
1368. A mass of iron in the Duchy of Oldenburgh.—*Subrand, Meyer.*
1379, May 26. Stones fell at Minden in Hanover.—*Lerbecius.*
1438. A shower of spongy stones at Roa, near Burgos in Spain.—*Proust.*
—— A stone fell near Lucerne.—*Cysat.*
1491, March 22. A stone fell near Crema.—*Simoneta.*
1492, Nov. 7. A stone of 260 lb. fell at Ensisheim near Sturgau, in Alsace. It is now in the library of Colmar, and has been reduced to 150 lb.—Trithemius, *Hirsaug. Annal. Conrad Gesner, Liber de Rerum Fossilium Figuris*, cap. 3.

p. 66, in his *Opera*, *Zurich*, 1565.

1496, Jan. 26, or 28. Three stones fell between Cesena and Bertonori.—*Buriel* and *Sabellicus*.

1510. About 1200 stones, one of which weighed 120 lb. and others 60 lb. fell in a field near the river Abdua.—"*Color ferrugineus, durities eximia, odor sulphureus.*" —Surius, *Comment.* Cardan, *De rerum Varietate*, lib. xiv. c. 72.

1511, Sept. 4. Several stones, some of which weighed 11 lb. and others 8 lb. fell at Crema.—*Giovanni del Prato*, and others.

1520, May. Stones fell in Arragon. —*Diego de Sayas*.

1540, April 28. A stone fell in the Limousin.—*Bonab. de St. Amable*.

Between 1540 and 1550. A mass of iron fell in the forest of Naunhoff.—*Chronicle of the Mines of Misnia*.

—— Iron fell in Piedmont.—*Mercati* and *Scaliger*.

1548, Nov. 6. A black mass fell at Mansfeld in Thuringia.—*Bonav. de St. Amable*.

1552, May 19. Stones fell in Thuringia near Schlossingen.—*Spangenberg*.

1559. Two large stones, as large as a man's head, fell at Miscolz in Hungary, which are said to be preserved in the Treasury at Vienna.—*Sthuansi*.

1561, May 17. A stone called the *Ara Julia*, fell at Torgau and Eilenborg. *Gesner* and *de Boot*.

1580, May 27. Stones fell near Gottingen.—*Barge*.

1581, July 26. A stone, 39 lb. weight, fell in Thuringia. It was so hot that no person could touch it.—*Binhard*, *Olearius*.

1583, Jan. 9. Stones fell at Castrovillari.—*Casto*, *Mercati*, and *Imperati*.

—— in the Ides of Jan. A stone of 30 lb. resembling iron, fell at Rosa in Lavadie.

—— March 2. A stone fell in Piedmont of the size of a grenade.

1591, June 19. Some large stones fell at Kunersdof.—*Lucas*.

1596, March 1. Stones fell at Crevalcose.—*Mittarelli*.

In the *Sixteenth Century*, not in 1603. A stone fell in the kingdom of Valencia.—*Cæsius* and the *Jesuits of Coimbra*.

1618, August. A great fall of stones took place in Styria.—*Stammes*.

—— A metallic mass fell in Bohemia.—*Khronland*.

1621, April 17. A mass of iron fell about 100 miles S. E. of Lahore. —*Jehan Guir's Memoirs*.

1622, Jan. 10. A stone fell in Devonshire.—*Rumph*.

1628, April 9. Stones fell near Hatford in Berkshire; one of them weighed 24 lb.—*Gent. Mag.* Dec. 1796.

1634, Oct. 27. Stones fell in Charollois.—*Morinus*.

1635, June 21. A stone fell in Vago in Italy.

—— July 7, or Sept. 29. A stone, weighing about 11 oz. fell at Calce.—*Valisnieri*, *Opere*, vi. 64.

1636, March 6. A burnt looking stone fell between Sagan and Dubrow in Silesia.—*Lucas* and *Cluverius*.

1637, Nov. 29. Gassendi says, a stone of a black metallic colour, fell on Mount Vaison, between Guilhaume and Perne in Provence. It weighed 54 lb. and had the size and shape of the human head. Its specific gravity was 3.5. *Gassendi*, *Opera*, p. 96. Lyons, 1658.

1642, August 4. A stone weighing 4 lb. fell between Woodbridge and Aldborough in Suffolk.—*Gent. Mag.* Dec. 1796.

1643, or 1644. Stones fell in the sea.—*Wurfbrain*.

1647, Feb. 18. A stone fell near Zwickau.—*Schmid*.

—— August. Stones fell in the bailiage of Stolzenau in Westphalia.—*Gilbert's Annal*.

Between 1647 and 1654. A mass fell in the sea.—*Willman*.

1650, August 6. A stone fell at Dordrecht.—*Senguerd*.

1654, March 30. Stones fell in the Island of Funen. *Bartholinus*.

A large stone fell at Warsaw.—*Petr. Borellus*.

A small stone fell at Milan, and killed a Franciscan.—*Museum Septalianum*.

1668, June 19, or 21. Two stones, one 300 lb. and the other 200 lb. weight, fell near Verona.—Legallois, *Conversations*, &c. Paris

1672, Valisnieri, *Opere*, ii. p. 64, 66. *Montanan* and *Francisco Carli*, who published a letter, containing several curious notices respecting the fall of stones from the heavens.

1671, Feb. 27. Stones fell in Suabia.—*Gilbert's Annal.* tom. xxxiii.

1673. A stone fell in the fields near Dietling.—"*Nostris temporibus in partibus Galliæ Cispadanæ, lapis magnæ quantitatis è nubibus cecidit.*"—See Leonardus, *de Gemmis*, lib. i. cap. 5.; and *Memorie della Societa Colombaria Fiorentina*, 1747, vol. i. diss. vi. p. 14.

1674, Oct. 6. Two large stones fell near Glaris.—*Scheuchzer.*

Between 1675 and 1677. A stone fell into a fishing boat near Copinshaw. — Wallace's *Account of Orkney*, and *Gent. Mag.* July 1806.

1677, May 28. Several stones, which probably contained copper, fell at Ermundorf near Roosenhaven. —Misi, *Nat. Cur.* 1677. App.

1680, May 18. Stones fell at London.—*King.*

1697, Jan. 13. Stones fell at Pentolina near Sienna.—*Soldani* after *Gabrieli.*

1698, May 19. A stone fell at Walhing.—*Scheuchzer.*

1706, June 7. A stone of 72 lb. fell at Larissa in Macedonia. It smelled of sulphur, and was like the scum of iron.—*Paul Lucas.*

1722, June 5. Stones fell near Schettlas in Freisingen.—*Meichelbeck.*

1723, June 22. About 33 stones, black and metallic, fell near Plestowitz in Bohemia.—*Rost* and *Stepling.*

1727, July 22. Stones fell at Lilaschitz in Bohemia.—*Stepling.*

1738, August 18. Stones fell near Carpentras.—*Castillon.*

1740, Oct. 25. Stones fell at Rasgrad.—*Gilbert's Annal.* tom. 1.

—— to 1741. A large stone fell in winter in Greenland.—*Egede.*

1748. Stones fell at Liboschitz in Bohemia.—*Stepling.*

1750, Oct. 1. A large stone fell at Niort near Coutances. — *Huard* and *Lalande.*

1751, May 26. Two masses of iron of 71 lb. and 16 lb. fell in the district of Agram, the capital of Croatia. The largest of these is now in Vienna.

1753, Jan. A stone fell in Germany, in Eichstadt. — *Cavallo*, iv. 377.

—— July 3. Four stones, one of which weighed 13 lb. fell at Strkow near Tabor. — *Stepling*, "*De Pluvia lapidea, anni* 1753, *ad Strkow, et ejus causis, meditatio,*" p. 4.—Prag. 1754.

—— Sept. Two stones, one of 20 lb. and the other of 11 lb. fell near the villages of Liponas and Pin in Brene. — *Lalande* and *Richard.*

1755, July. A stone fell in Calabria, at Terranuova, which weighed 7 lb. 7½ oz.—*Domin. Tata.*

1766, end of July. A stone fell at Albereto in Modena.—*Troili.*

—— August 15. A stone fell at Novellara.—*Troili.*

1768, Sept. 13. A stone fell near Luce in Maine. It was analyzed by Lavoisier, &c.—*Mem. Acad. Par.*

—— A stone fell at Aire.—*Mem. Acad. Par.*

1768, Nov. 20. A stone, weighing 38 lb. fell at Mauerkirchen in Bavaria.—*Imhof.*

1773, Nov. 17. A stone, weighing 9 lb. 1 oz. fell at Sena in Arragon. —*Proust.*

1775, Sept. 19. Stones fell near Rodach in Cobourg. — *Gilbert's Annal.* tom. xxiii.

—— or 1776. Stones fell at Obruteza in Volhynia.—*Gilbert's Annal.* tom. xxxi.

1776 or 1777, Jan. or Feb. Stones fell near Fabriano.—*Soldani* and *Amoretti.*

1779. Two stones, weighing 3½ oz. each, fell at Pettiswoode in Ireland.— *Bingley*, in *Gent. Mag.* Sept. 1796.

1780, April 1. Stones fell near Beeston in England. — *Evening Post.*

1782. A stone fell near Turin.— *Tata* and *Amoretti.*

1785, Feb. 19. Stones fell at Eichstadt.— *Pickel* and *Stutz.*

1787, Oct. 1. Stones fell in the province of Charkow in Russia.— *Gilbert's Annal.* tom. xxxi.

1790, July 24. A great shower of stones fell at Barbotan near Roquefort, in the vicinity of Bour-

deaux. A mass, 15 inches in diameter, penetrated a hut, and killed a herdsman and a bullock. Some of the stones weighed 25 lb. and others 30 lb.—*Lomet.*

1791, May 17. Stones fell at Cassel-Berardenga, in Tuscany.—*Soldani.*

1794, June 16. Twelve stones, one of which weighed 7½ oz. fell at Sienna. Howard and Klaproth have analyzed these stones.—*Phil. Trans.* 1794, p. 103.

1795, April 13. Stones fell at Ceylon.—*Beck.*

—— Dec. 13. A large stone weighing 55 lb. fell near Wold Cottage in Yorkshire. No light accompanied the fall.—*Gent. Mag.* 1796.

1796, Jan. 4. Stones fell near Belaja Ferkwa in Russia.—*Gilbert's Annal.* tom. xxxv.

—— Feb. 19. A stone of 10 lb. fell in Portugal.—Southey's *Letters from Spain.*

1798, March 8, or 12. Stones, one of which was the size of a calf's head, fell at Sales.—*Marquis de Drée.*

—— Dec. 19. Stones fell in Bengal.—*Howard, Lord Valentia.*

1799, April 5. Stones fell at Batanrouge on the Mississippi.—*Belfast Chronicle of the War.*

1801. Stones fell on the Island of Tonneliers.—*Bory de St. Vincent.*

1802, Sept. Stones fell in Scotland! *Monthly Magazine*, Oct. 1802.

1803, April 26. A great fall of stones took place at Aigle. They were about three thousand in number, and the largest weighed about 17 lb.

—— Oct. 5. Stones fell near Avignon. *Bibl. Brit.*

—— Dec. 13. A stone fell near Eggenfelde in Bavaria, weighing 3½ lb.—*Imhof.*

1804, April 5. A stone fell at Possil, near Glasgow.

—— —— 1807. A stone fell at Dordrecht.—*Van Beck. Calkoen.*

1805, March 25. Stones fell at Doroninsk in Siberia.—*Gilbert's Annal.* tom. xxix. and xxxi.

—— June. Stones, covered with a black crust, fell in Constantinople.

1806, March 15. Two stones fell at St. Etienne and Valence; one of them weighed 8 lb.

1806, May 17. A stone weighing 2½ lb. fell near Basingstoke in Hampshire.—*Monthly Magazine.*

1807, March 13. (June 17, according to Lucas.) A stone of 160 lb. fell at Fimochin, in the province of Smolensko in Russia.—*Gilbert's Annal.*

—— Dec. 14. A great shower of stones fell near Weston in Connecticut. Masses of 20 lb. 25 lb. and 35 lb. were found.—*Silliman* and *Kingsley.*

1808, April 19. Stones fell at Borgo San-Donino.—*Guidotti* and *Spagnoni.*

—— May 22. Stones weighing 4 lb. or 5 lb. fell near Stannern in Moravia.—*Bibl. Brit.*

—— Sept. 3. Stones fell at Lissa in Bohemia.—*De Schreibers.*

1809, June 17. A stone of 6 oz. fell on board an American vessel, in latitude 30° 58′ N., and longitude 70° 25′ W.—*Bibl. Brit.*

1810, Jan. 30. Stones, some of which weighed about 2 lb. fell in Caswell county, North America. *Phil. Mag.* vol. xxxvi.

—— July. A great stone fell at Shahabad in India. It burned five villages, and killed several men and women.—*Phil. Mag.* xxxvii. p. 236.

—— Aug. 10. A stone weighing 7¾ lb. fell in the county of Tipperary in Ireland.—*Phil. Mag.* vol. xxxviii.

—— Nov. 23. Stones fell at Mortelle, Villerai, and Moulinbrule, in the department of the Loiret; one of them weighed 40 lb. and the other 20 lb. *Nich. Journal.* vol. xxxix. p. 158.

1811, March 12, or 13. A stone of 15 lb. fell in the village of Kongunbowsh, near Romea in Russia.—Bruce's *American Journal.* No. 3.

—— July 8. Stones, one of which weighed 3½ oz. fell near Balanguillas in Spain.—*Bibl. Brit.* tom. xlviii. p. 162.

1812, April 10. A shower of stones fell near Thoulouse.

—— April 15. A stone, the size of a child's head, fell at Erxleben. A specimen of it is in the possession of Professor Haussman

of Brunswick.—*Gilbert's Annal.* xl. and xli.

1812, Aug. 5. Stones fell at Chantonay.—*Brochant.*

1813, March 14. Stones fell at Cutro in Calabria, during a great fall of red dust.—*Bibl. Brit.* Oct. 1813.

—— Sept. 9 and 10. Several stones, one of which weighed 17 lb. fell near Limerick in Ireland.—*Phil. Mag.*

1814, Feb. 3. A stone fell near Bacharut in Russia.—*Gilbert's Annal.* tom. 1.

—— Sept. 5. Stones, some of which weighed 18 lb. fell in the vicinity of Agen.—*Phil. Mag.* vol. xlv.

—— Nov. 5. Stones, of which 19 were found fell in the Doab in India.—*Phil. Mag.*

1815, Oct. 3. A large stone fell at Chassigny near Langres.—*Pistollet.*

1816. A stone fell at Glastonbury in Somersetshire.—*Phil. Mag.*

1817, May 2 and 3. There is reason to think, that masses of stone fell in the Baltic after the great meteor of Gottenburg.—*Chladni.*

1818, Feb. 15. A great stone appears to have fallen at Limoge, but it has not been disinterred.—*Gazette de France*, Feb. 25, 1818.

—— July 29, O. S. A stone of 7 lb. fell at the village of Slobodka in Smolensko. It penetrated nearly 16 inches into the ground. It had a brown crust with metallic spots.

LIST OF MASSES OF IRON SUPPOSED TO HAVE FALLEN FROM THE HEAVENS.

Sect. 1.—*Spongy or Sellular Masses containing Nickel.*

1. The mass found by Pallas in Siberia, to which the Tartars ascribe a meteoric origin.—*Voyages de Pallas*, tom. iv. p. 545. *Paris*, 1793.
2. A fragment found between Eibenstock and Johanngeorgenstadt.
3. A fragment probably from Norway, and in the imperial cabinet of Vienna.
4. A small mass, weighing some pounds, and now at Gotha.
5. Two masses in Greenland, out of which the knives of the Esquimaux were made.—See Ross's *Account of an Expedition to the Arctic Regions.*

Sect. 2.—*Solid Masses where the Iron exists in Rhomboids or Octohedrons, composed of Strata, and containing Nickel.*

1. The only fall of iron of this kind, is that which took place at Agram, in 1751.
2. A mass of the same kind has been found on the right bank of the Senegal.—*Compagnon, Forster*, and *Goldberry.*
3. At the Cape of Good Hope; Stromeyer has lately detected cobalt in this mass.—*Van Marum* and *Dankelman; Brande's Journal*, vol. vi. 162.
4. In different parts of Mexico.—*Sonneschmidt, Humboldt*, and the *Gazette de Mexico*, tom. i. and v.
5. In the province of Bahia in Brazil. It is seven feet long, four feet wide, and two feet thick, and its weight about 14,000 lb.—*Mornay* and *Wollaston; Phil. Trans.* 1816, p. 270, 281.
6. In the jurisdiction of San Jago del Estera.—*Rubin de Callis*, in the *Phil. Trans.* 1788, vol. lxxviii. p. 37.
7. At Elbogen in Bohemia.—*Gilbert's Annal.* xlii. and xliv.
8. Near Lenarto in Hungary.—*Ditto*, xlix.

The origin of the following masses seems to be uncertain, as they do not contain nickel, and have a different texture from the preceding:—

1. A mass found near the Red River, and sent from New Orleans to New York.—*Journ. des Mines*, 1812, *Bruce's Journ.*
2. A mass at Aix-la-Chapelle containing arsenic.—*Gilbert's Annal.* xlviii.
3. A mass found on the hill of Brianza in the Milanese.—*Chladni* in *Gilbert's Annal.* l. p. 275.
4. A mass found at Groskamdorf, and containing, according to Klaproth, a little lead and copper.

There is not, perhaps, any thing in the history of science more extraordinary and curious than the fall of so many stones from the air; and the attention of chemists has been directed to analyze them, to ascertain of what they are composed. They have been found to consist almost always of the same component parts; and altogether independent in their formation, and distinct from the substances contained in the neighbourhood where they have fallen. They have been found to have a thin dark crust on the outside without gloss, with some asperities. Internally they are greyish, of a granulated texture, more or less fine. The crust is hard enough to emit sparks with steel, and may be broken by a slight blow of a hammer. It appears to have the properties of attractable oxide of iron. The crust for the most part contains nickel combined with iron; in some instances nickel has not been found; but chromium has always been found, and is, therefore, deemed the constant characteristic of aerolites. Martial pyrites is also found in aerolites of a reddish colour, black when powdered, not very firm in its texture, and not attractable by the magnet. The pyrites examined by Mr. Herschel, was found to contain—

Iron	68
Sulphur	13
Nickel	6
Extraneous earthy matter	13
	100

In the metallic particles diffused through the mass, the nickel was in the proportion of one part to three of iron. The small particles of iron in a perfectly metallic state, give to the whole mass the quality of being attracted by the magnet. The whole is connected together by a substance of earthy consistence, in most so soft, that it may easily be broken by the fingers. Magnesia and silex are the earths found in aerolites.

Solitary masses of iron have been found in Siberia, Senegal, and South America, which have been found on examination to contain nickel, and to be of a cellular texture, or to have earthy matter disseminated amongst the metal: hence, these masses of iron have been supposed to be of meteoric origin.

In all instances where authentic accounts have been given of the fall of aerolites, there has been seen a luminous meteor, exploding with a loud noise immediately preceding the fall, and this has been supposed to be the cause. These stones, also, if they were handled soon after their fall, were found to be hot. This has induced some to consider whether these bodies might not have at the time brought together firm matter floating in the atmosphere. Others have supposed that they might have been projected from volcanoes; whilst some have suggested that they might be bodies wandering through space, and at length brought within the sphere of the earth's attraction. There is another opinion, which ascribes the origin of these bodies to the moon, from which they are supposed to be projected by the force of immense volcanoes; and calculations have been made by which it has been endeavoured to shew, that the power necessary in a lunar volcano to project an aerolite beyond the sphere of the moon's attraction, and within that of the earth, was no way so great, but that the lunar volcanoes might be supposed to possess it.

Tools made of iron, alloyed with nickel, were found in possession of the natives of the coast of Baffin's bay, by the navigators sent out to explore the Arctic regions. It is supposed to be of meteoric origin. The phenomenon of red snow seen both on the coast of Baffin's bay and at Spitzbergen attracted much attention. This colouring matter has been found to have its origin from a very minute fungus which grows upon the snow, and which has been considered a species of uredo, and has been denominated uredo nivalis.

AEROMETER. An instrument to ascertain the bulk of the gases in pneumatic experiments.

AEROSTATION is the art of causing balloons to ascend in the air.

This subject belongs to natural philosophy.

ÆTITES, OR EAGLE STONE, is a name that has been given to a kind of hollow geodes of oxide of iron, often mixed with a larger or smaller quantity of silex and alumina, containing in their cavity some concretions, which rattle on shaking the stone. It is of a dull pale colour, composed of concentric layers of various magnitudes, of an oval or polygonal form, and often polished. Eagles were said to carry them to their nests, whence their name; and superstition formerly ascribed wonderful virtues to them.

AFFINITY. See ATTRACTION.

AGALMATOLITE, BILDSTEIN, OR FIGURE-STONE, is a mineral found in China, and brought thence cut into grotesque figures. It differs from steatites in not containing any magnesia. It has been found at Naygag in Transylvania and Glyderbeck in Wales. It is translucent on the edges, unctuous to the touch, and yields to the nail. Specific gravity 2.8. It fuses into a transparent glass.

AGARICUS. The mushroom, a genus of the order Fungi. Mushrooms appear to approach nearer to the nature of animal matter, than any other productions of the vegetable kingdom, as, besides hydrogen, oxygen, and carbon, they contain a considerable portion of nitrogen, and yield ammonia by distillation. Prof. Proust has likewise discovered in them the benzoic acid, and phosphate of lime.

A few of the species are eaten in this country, but many are recorded to have produced poisonous effects; though in some foreign countries, particularly in Russia, very few are rejected. Perhaps it is of importance, that they should be fresh, thoroughly dressed, and not of a coriaceous texture. The Russians, however, are very fond of the *A. piperatus*, which we deem poisonous, preserved with salt throughout the winter: and our *ketchup* is made by sprinkling mushrooms with salt, and letting them stand till great part is resolved into a brown liquor, which is then boiled up with spices. The *A. piperatus* has been recommended in France to consumptive people. The *A. muscarius* has been prescribed in doses of a few grains in cases of epilepsy and palsy, subsequent to the drying up of eruptions.

In pharmacy two species of *boletus* have formerly been used under the name of agaric. The *B. pini laricis*, or *male agaric* of the shops, was given as a purgative, either in substance, or in an extract made with vinegar, wine, or an alkaline solution: and the *B. igniarius*, spunk, or touchwood, called female agaric, was applied externally as a styptic, even after amputations. For this purpose the soft inner substance was taken, and beaten with a hammer to render it still softer. That of the oak was preferred.

Modern chemists in analyzing mushrooms have discovered an insoluble portion resembling woody fibre, yet being less soluble in alkalis, and yielding a nutritive food, has been considered a peculiar product, and has been denominated fungin. Two new acids, the boletic and the fungic, have also been the result of these researches.

AGARICUS MINERALIS, the *mountain milk*, or *mountain meal*, of the Germans, is one of the purest of the native carbonates of lime, found chiefly in the clefts of rocks, and at the bottom of some lakes, in a loose or semi-indurated form. It has been used internally in hæmorrhages, stranguary, gravel, and dysenteries; and externally as an application to old ulcers, and weak and watery eyes.

M. Fabroni calls by the name of *mineral agaric*, or *fossil meal*, a stone of a loose consistence found in Tuscany in considerable abundance, of which bricks may be made, either with or without the addition of a twentieth part of argil, so light as to float in water; and which he supposes the ancients used for making their floating bricks. This, however, is very different from the preceding, not being even of the calcareous genus, since it appears, on analysis, to consist of silex 55 parts, magnesia 15, water 14, argil 12, lime 3,

iron 1. Kirwan calls it *argillo-murite*.

AGGREGATE. When bodies of the same kind are united, the only consequence is, that one larger body is produced. In this case, the united mass is called an aggregate, and does not differ in its chemical properties from the bodies from which it was originally made. Elementary writers call the smallest parts into which an aggregate can be divided without destroying its chemical properties, integrant parts. Thus, the integrant parts of common salt are the smallest parts which can be conceived to remain without change; and beyond these, any further subdivision cannot be made without developing the component parts, namely, the alkali and the acid; which are still further resolvable into their constituent principles.

AGRICULTURAL CHEMISTRY is the science by which chemical knowledge is applied to effect improvements in the cultivation of the soil. Dr. Coventry, Professor of Agriculture in the University of Edinburgh, has diffused much knowledge in this subject; and Sir Humphrey Davy's Lectures on Agricultural Chemistry, are a treasure of knowledge to every enlightened cultivator.

Agricultural chemistry, according to Sir H. Davy, has for its objects all those changes in the arrangements of matter connected with the growth and nourishment of plants; the comparative values of their produce as food; the constitution of soils; the manner in which lands are enriched by manure, or rendered fertile by the different processes of cultivation. Inquiries of such a nature cannot but be interesting and important, both to the theoretical agriculturist, and to the practical farmer. To the first, they are necessary in supplying most of the fundamental principles on which the theory of the art depends. To the second, they are useful in affording simple and easy experiments for directing his labours, and for enabling him to pursue a certain and systematic plan of improvement.

It is scarcely possible to enter upon any investigation in agriculture without finding it connected, more or less, with doctrines or elucidations derived from chemistry.

If land be unproductive, and a system of ameliorating it is to be attempted, the sure method of obtaining the object is by determining the cause of its sterility, which must necessarily depend upon some defect in the constitution of the soil, which may be easily discocovered by chemical analysis.

Some lands of good apparent texture are yet sterile in a high degree; and common observation and common practice afford no means of ascertaining the cause, or of removing the effect. The application of chemical tests in such cases is obvious; for the soil must contain some noxious principle which may be easily discovered, and probably easily destroyed.

Are any of the salts of iron present? they may be decomposed by lime. Is there an excess of silicious sand? the system of improvement must depend on the application of clay and calcareous matter. Is there a defect of calcareous matter? the remedy is obvious. Is an excess of vegetable matter indicated? it may be removed by liming, paring, and burning. Is there a deficiency of vegetable matter? it is to be supplied by manure.

A question concerning the different kinds of limestone to be employed in cultivation often occurs. To determine this fully in the common way of experience, would demand a considerable time, perhaps some years, and trials which might be injurious to crops; but by simple chemical tests the nature of a limestone is discovered in a few minutes; and the fitness of its application, whether as a manure for different soils, or as a cement, determined.

Peat earth of a certain consistence and composition is an excellent manure; but there are some varieties of peats which contain so large a quantity of ferruginous matter as to be absolutely poisonous to plants. Nothing can be more simple than the chemical operation

for determining the nature, and the probable uses of a substance of this kind.

There has been no question on which more difference of opinion has existed, than that of the state in which manure ought to be ploughed into the land; whether recent, or when it has gone through the process of fermentation: and this question is still a subject of discussion; but whoever will refer to the simplest principles of chemistry, cannot entertain a doubt on the subject. As soon as dung begins to decompose, it throws off its volatile parts, which are the most valuable and most efficient. Dung which has fermented, so as to become a mere soft cohesive mass, has generally lost from one-third to one-half of its most useful constituent elements. It evidently should be applied as soon as fermentation begins, that it may exert its full action upon the plant, and lose none of its nutritive powers.

It would be easy to adduce a multitude of other instances of the same kind; but sufficient has been said to prove, that the connection of chemistry with agriculture is not founded on mere vague speculation, but that it offers principles which ought to be understood and followed, and which in their progression and ultimate results, can hardly fail to be highly beneficial to the community.

AIR was, till lately, used as the generic name for such invisible and exceedingly rare fluids as possess a very high degree of elasticity, and are not condensable into the liquid state by any degree of cold hitherto produced; but as this term is commonly employed to signify that compound of aeriform fluids which constitutes our atmosphere, it has been deemed advisable to restrict it to this signification, and to employ as the generic term the word GAS, for the different kinds of air, except what relates to our atmospheric compound.

AIR (ATMOSPHERICAL OR COMMON.) The immense mass of permanently elastic fluid which surrounds the globe we inhabit, must consist of a general assemblage of every kind of air which can be formed by the various bodies that compose its surface. Most of these, however, are absorbed by water: a number of them are decomposed by combination with each other; and some of them are seldom disengaged in considerable quantities by the processes of nature. Hence it is that the lower atmosphere consists chiefly of oxygen and nitrogen, together with moisture and the occasional vapours or exhalations of bodies. The upper atmosphere seems to be composed of a large proportion of hydrogen, a fluid of so much less specific gravity than any other, that it must naturally ascend to the highest place, where, being occasionally set on fire by electricity, it appears to be the cause of the aurora borealis and fire-balls. It may easily be understood, that this will only happen on the confines of the respective masses of common atmospherical air, and of the inflammable air; that the combustion will extend progressively, though rapidly, in flashings from the place where it commences; and that when, by any means, a steam of inflammable air, in its progress toward the upper atmosphere, is set on fire at one end, its ignition may be much more rapid than what happens higher up, where oxygen is wanting, and at the same time more definite in its figure and progression, so as to form the appearance of a fire-ball.

That the air of the atmosphere is so transparent as to be invisible, except by the blue colour it reflects when in very large masses, as is seen in the sky or region above us, or in viewing extensive landscapes; that it is without smell, except that of electricity, which it sometimes very manifestly exhibits; altogether without taste, and impalpable; not condensable by any degree of cold into the dense fluid state, though easily changing its dimensions with its temperature; that it gravitates and is highly elastic, are among the numerous observations and discoveries which do honour to the sagacity of the philosophers of the seventeenth century. They likewise knew that this fluid is indispensably necessary

to combustion; but no one, except the great, though neglected, John Mayow, appears to have formed any proper notion of its manner of acting in that process.

The air of the atmosphere, like other fluids, appears to be capable of holding bodies in solution. It takes up water in considerable quantities, with a diminution of its own specific gravity; from which circumstance, as well as from the consideration that water rises very plentifully in the vaporous state *in vacuo*, it seems probable, that the air suspends vapour, not so much by a real solution, as by keeping its particles asunder, and preventing their condensation. Water likewise dissolves or absorbs air.

Mere heating or cooling does not affect the chemical properties of atmospherical air; but actual combustion, or any process of the same nature, combines its oxygen, and leaves its nitrogen separate. Whenever a process of this kind is carried on in a vessel containing atmospherical air, which is enclosed either by inverting the vessel over mercury, or by stopping its aperture in a proper manner, it is found that the process ceases after a certain time; and that the remaining air (if a combustible body capable of solidifying the oxygen, such as phosphorus, have been employed) has lost about a fifth part of its volume, and is of such a nature as to be incapable of maintaining any combustion for a second time, or of supporting the life of animals. From these experiments it is clear, that one of the following deductions must be true:—1. The combustible body has emitted some principle, which, by combining with the air, has rendered it unfit for the purpose of further combustion; or, 2. It has absorbed part of the air which was fit for that purpose, and has left a residue of a different nature; or, 3. Both events have happened, namely, that the pure part of the air has been absorbed, and a principle has been emitted, which has changed the original properties of the remainder.

It has been sufficiently proved by various experiments, that combustible bodies take oxygen from the atmosphere, and leave nitrogen; and that when these two fluids are again mixed, in due proportions, they compose a mixture not differing from atmospherical air.

The respiration of animals produces the same effect on atmospherical air as combustion does, and their constant heat appears to be an effect of the same nature. When an animal is included in a limited quantity of atmospherical air, it dies as soon as the oxygen is consumed; and no other air will maintain animal life but oxygen, or a mixture which contains it. Pure oxygen maintains the life of animals much longer than atmospherical air, bulk for bulk.

In addition to the other substances in the air, there is also carbonic acid gas, which is constantly forming by the combustion of wood, coals, and other carbonaceous matter, during which the oxygen of the air enters into combination with the carbon, and forms this gas. A large portion is also continually produced by the breathing of animals, by which operation the oxygen of the air is separated from the nitrogen, and united with carbon in the lungs, when it is emitted again in the form of carbonic acid gas.

There are many provisions in nature by which the proportion of oxygen in the atmosphere, which is continually consumed in respiration and combustion, is again restored to that fluid. In fact there appears, as far as an estimate can be formed of the great and general operations of nature, to be at least as great an emission of oxygen, as is sufficient to keep the general mass of the atmosphere at the same degree of purity. Thus, in volcanic eruptions there seems to be at least as much oxygen emitted or extricated by fire, from various minerals, as is sufficient to maintain the combustion, and perhaps even to meliorate the atmosphere. And in the bodies of plants and animals, which appear in a great measure to derive their sustenance and augmentation from the atmosphere and its contents, it is found that a

large proportion of nitrogen exists. Most plants emit oxygen in the sunshine, from which it is highly probable that they imbibe and decompose the air of the atmosphere, retaining carbon, and emitting the vital part. Lastly, if to this we add the decomposition of water, there will be numerous occasions in which this fluid will supply us with disengaged oxygen; while, by a very rational supposition, its hydrogen may be considered as having entered into the bodies of plants for the formation of oils, sugars, mucilages, &c. from which it may be again extricated.

To determine the respirability or purity of air, it is evident that recourse must be had to its comparative efficacy in maintaining combustion, or some other equivalent process. This subject will be considered under the article EUDIOMETER.

From the latest and most accurate experiments, the proportion of oxygen in atmospheric air is by measure about 21 per cent.; and it appears to be very nearly the same, whether it be in this country or on the coast of Guinea, on low plains or lofty mountains, or even at the height of 7250 yards above the level of the sea, as ascertained by Gay Lussac in his aerial voyage in September 1805. The remainder of the air is nitrogen, with a small portion of aqueous vapour, amounting to about 1 per cent. in the driest weather, and a still less portion of carbonic acid, not exceeding a thousandth part of the whole.

It has long been a matter of difficulty with philosophers to determine whether oxygen and nitrogen gases in the atmosphere were chemically united, or whether they were merely mechanically mixed together. It is certain that in the atmosphere both gases retain their peculiar properties, which two seldom do when they unite chemically, but usually make a new substance essentially differing from either; also, there is no change of temperature or density in their union, which also usually occur in the case of chemical union. From these circumstances, it would be natural to infer, that the two gases were merely, mechanically mixed together; but then, as they differ in specific gravity, the oxygen being heavier than nitrogen, nearly in the proportion of seven to six, it might be expected that if there were no chemical union, they would separate, and there would be a larger portion of oxygen in the lower strata of the atmosphere, and a larger portion of nitrogen in the higher; but this is not the case; for the air obtained at the summit of Mont Blanc, or in the far highest regions of the atmosphere to which aeronauts have ascended, have been found upon analyzing, to contain precisely the same proportions of component parts as air found in the bottom of the valley. It follows, therefore, that if there be not a chemical union, there is, at least, such an attraction between the particles of oxygen and nitrogen, as is sufficient to overcome their tendency to separate by their difference of specific gravity.

It is an exceedingly difficult matter to determine, with any degree of accuracy, the specific gravity of the air, or of any of the gases; but according to the experiments of M. Biot and M. Arago, at 60° Fahrenheit, and the barometer at 30 inches, the weight of air is $\frac{1}{820}$ part that of water; or expressed without a fraction he stated, 100,000 atmospheric air, will be 122 of water. In regard to the proportions of oxygen and nitrogen in the atmosphere

Oxygen is . . .	21
Nitrogen	79
	100

It is not absolutely determined, however, whether the proportions might not more properly be,

Oxygen	20
Nitrogen	80
	100

ALABASTER. Among the stones which are known by the name of marble, and have been distinguished by a considerable variety of denominations by statuaries, and others, whose attention is more directed to their external character and appearance than their

component parts, alabasters are those which have a greater or less degree of imperfect transparency, a granular texture, are softer, take a duller polish than marble, and are usually of a whiter colour. Some stones, however, of a veined and coloured appearance, have been considered as alabasters, from their possessing the first mentioned criterion; and some transparent and yellow sparry stones have also received this appellation.

Chemists are at present agreed in applying this name only to such opaque, consistent, and semi-transparent stones, as are composed of lime united with the sulphuric acid. But the term is much more frequent among masons and statuaries than chemists. Chemists in general confound the alabasters among the selenites, gypsums, or plaster of Paris, more especially when they allude only to the component parts, without having occasion to consider the external appearance, in which only these several compounds differ from each other.

As the semi-opaque appearance and granular texture arise merely from a disturbed or successive crystallization, which would else have formed transparent spars, it is accordingly found, that the calcareous stalactites, or drop-stones, formed by the transition of water through the roofs of caverns in a calcareous soil, do not differ in appearance from the alabaster, most of which is also formed in this manner. But the calcareous stalactites here spoken of, consist of calcareous earth and carbonic acid, while the alabaster of the chemists is formed of the same earth and sulphuric acid, as has already been remarked.

ALBIN. This name was given to a mineral discovered by Werner, in *Bohemia*, on account of its white colour. It is opaque. Massive albin consists of aggregated crystalline laminæ; but there are small crystals of it in right prisms, whose summits consist of rectangular planes, sprinkled over mammelated masses in cavities.

ALBUM GRÆCUM. Innumerable are the instances of fanciful speculation and absurd credulity in the invention and application of subjects in the more ancient materia medica. The white and solid excrement of dogs, which subsist chiefly on bones, has been received as a remedy in the medical art, under the name of Album Græcum. It consists, for the most part, of the earth of bones or lime, in combination with phosphoric acid.

ALBUMEN. This substance, which derives its name from the Latin for the white of an egg, in which it exists abundantly, and in its purest natural state, is one of the chief constituent principles of all the animal solids. Beside the white of egg, it abounds in the serum of blood, the vitreous and crystalline humours of the eye, and the fluid of dropsy. Fourcroy claims to himself the honour of having discovered it in the green fecula of plants in general, particularly in those of the cruciform order, in very young ones, and in the fresh shoots of trees, though Rouelle appears to have detected it there long before. Vauquelin says it exists also in the mineral water of Plombieres.

Mr. Seguin has found it in remarkable quantity in such vegetables as ferment without yeast, and afford a vinous liquor; and from a series of experiments he infers, that albumen is the true principle of fermentation, and that its action is more powerful in proportion to its solubility, three different degrees of which he found it to possess.

The chief characteristic of albumen is its coagulability by the action of heat. If the white of an egg be exposed to a heat of about 134° F. white fibres begin to appear in it, and at 160° it coagulates into a solid mass. In a heat not exceeding 212° it dries, shrinks, and assumes the appearance of horn. It is soluble in cold water before it has been coagulated, but not after: and when diluted with a very large portion it does not coagulate easily. Pure alkalis dissolve it, even after coagulation. It is precipitated by muriate of mercury, nitro muriate of tin, acetate of lead, nitrate of silver, mu-

riate of gold, infusion of galls, and tannin. The acids and metallic oxides coagulate albumen. On the addition of concentrated sulphuric acid, it becomes black, and exhales a nauseous smell. Strong muriatic acid gives a violet tinge to the coagulum, and at length becomes saturated with ammonia. Nitric acid, at 70° F. disengages from it abundance of azotic gas; and if the heat be increased prussic acid is formed, after which carbonic acid and carburetted hydrogen are evolved, and the residue consists of water containing a little oxalic acid, and covered with a lemon coloured fat oil. If dry potash or soda be triturated with albumen, either liquid or solid, ammoniacal gas is evolved, and the calcination of the residuum yields an alkaline prussiate.

On exposure to the atmosphere in a moist state, albumen passes at once to the state of putrefaction.

Albumen is easily obtained from the white of an egg by agitating it in ten or twelve times its weight of alcohol. The water which held the albumen in solution unites with the alcohol, and the albumen falls to the bottom in the form of white flakes or filaments, which are insoluble and may, therefore, be washed with water. This substance is readily dissolved in potash and soda, but with considerable difficulty in ammonia or the acetic acid. Albumen is solid, white, insipid, and inodorous, without action on vegetable colours.

According to the experiments of Gay Lussac and Thenard, 100 parts of albumen from the white of the egg are composed of

Carbon . . .	52.883
Oxygen . . .	23,872
Hydrogen . .	7.540
Azote . . .	15.705

This estimation would authorize the supposition, that albumen is composed of two proportions of azote, five oxygen, nine carbon, twenty two hydrogen.

The principal part of the almond, and of the kernels of many other nuts, appears, from the experiments of Proust, to be a substance analogous to coagulated albumen.

The juice of the fruit of the Ochra, (*Hibiscus esculentus*) according to Dr. Clarke, contains a liquid albumen in such quantities, that it is employed in Dominica as a substitute for the white of eggs in clarifying the juice of the sugar cane.

Albumen may be distinguished from other substances by its property of coagulating by the action of heat or acids, when dissolved in water. According to Dr. Bostock, when the solution contains only one grain of albumen to 1,000 grains of water, it becomes cloudy by being heated.

Albumen is a substance common to the animal as well as to the vegetable kingdom, and much more abundant in the former.

From its coagulability albumen is of great use in clarifying liquids.

It is likewise remarkable for the property of rendering leather supple, for which purpose a solution of whites of eggs in water is used by leather dressers; and hence Dr. Lobb, of Yeovil, in Somersetshire, was induced to employ this solution in cases of contraction and rigidity of the tendons, and derived from it apparent success.

Whites of eggs beaten in a basin with a lump of alum, till they coagulate, form the *alum curd* of Riverius, or *alum cataplasm* of the London Pharmacopœia, used to remove inflammations of the eyes.

ALBURNUM is the name given to the inner bark of trees.

ALCARRAZAS is a species of pottery made in Spain, used for cooling wines, which it effects by being porous, in consequence of which the wine passing through the pores is evaporated, and as in all other cases where evaporation takes place, cold is produced. This pottery is made of clay, consisting of sixty parts of calcareous earth, mixed with alumina, and a little peroxide of iron, and thirty six of silicious earth, mixed with a little alumina; to which a quantity of salt is added in the mixing. The vessels are only half baked.

ALCHEMY. For many ages, in almost all countries where science was in any degree cultivated, men were led to indulge in the absurd hope of being able to convert all

the inferior metals into gold and silver. The substance which was to effect this, has been called the philosopher's stone. There have also been imaginary hopes indulged of being able to discover a universal medicine, which would cure diseases, and confer long life or immortality. The desire of wealth and of life being engaged, it is not to be wondered, in the less enlightened ages, when so many of the properties of different kinds of matter were unknown, that chemists should eagerly persevere in the research; and hence the importance of alchemy, which was the name given to this pursuit. The alchemists, by performing every kind of experiment they could think of, although they failed in the chief object of their pursuit, made many discoveries which have been of benefit to mankind, and formed the basis of purer science in more enlightened ages. In perusing the history of the transactions of the alchemists, as recorded in the works of Boyle, Boerhaave, and other sober minded men, we meet with such evidence of the transmutation of the baser metals, that were it not now known by the aid of modern science that the matter is impossible, we should hardly know on what ground to refuse our belief. Even Lord Bacon was induced to believe in the *possibility* of the success of alchemy; and considering how plausible and numerous were the pretensions of the alchemists, he, perhaps, would hardly have been justifiable, with the knowledge then possessed of chemistry, to have maintained that success never could be obtained.

In the middle ages there were many pretenders who amassed property by pretending to communicate the important secret, and nobles, bishops, princes, and kings, were constantly their dupes. Frederick III. emperor of Germany, caused a medal to be struck of the gold produced by an alchemical operation, which was performed in his presence by a quack of the name of Richterhausen. Frederick was so well satisfied, that he granted letters of nobility to the adept, and called him up among the barons of the holy Roman empire by the appropriate title of the Baron of Chaos. Such a fief was worth a fortune, and accordingly wherever he went, the Baron of Chaos met with capital success. At the court of the elector of Mayence, he offered to effect a transmutation, for which purpose he produced a small portion of the matter of projection, in shape and size like a lentil. The powder had been mixed up with gum tragacanth, for the purpose, as he said, of binding it, and again the pellet was enveloped in wax. The elector was desired to put it together with four ounces of quicksilver in a crucible, which was afterwards covered with charcoal. The elector and the baron then blew the fire, and at the expiration of half an hour, the crucible was taken from the furnace, and the baron poured out the molten *gold*. The liquid metal appeared of a bright red, and the baron exclaimed that its touch was too high; it must be lowered by the addition of silver. The elector threw in a bar of silver, and after a second fusion, the metal was cast in an ingot, which was found very pure, but rather brittle. The baron easily accounted for this, by saying, probably, some particles of tin adhered to the ingot mould; but a third fusion would remove the alloy. This was done at the mint, and the gold then became exceedingly ductile, and the mint master told his serene highness he had never seen such fine gold. Moncounis tells the story in the words of the elector, and it is evident that both of them believed that a real transmutation had taken place.

In performing such experiments, it was a usual trick to have a piece of gold enclosed in a hollow tube employed to stir the mixture, and with the end stopped up with wax. In the process of stirring, the wax melting, allowed the gold to get into the crucible, and thus the alchemist succeeded in persuading his dupes that he had effected the purpose proposed.

John Henry Muller, originally a barber, in the province of Alsace,

came to the court of the emperor Rodolph, who was a munificent patron of occult sciences, and succeeded so well, that he had a patent of nobility conferred on him. After many adventures he went to the court of the Duke of Wurtemberg, at Stuttgard, to practise his art, and succeeded in persuading the duke of his effecting the transmutations. The duke poured the metals into the crucible, the doors of the laboratory were locked and sealed, and on the following morning the amalgam of lead and mercury was found richly impregnated with gold. Another operation at the castle of Reidlengen had the same effect. In the first case, success was obtained by means of an accomplice introduced in a chest; and in the second instance, the same useful auxiliary found his way through a vault. But the baron was not allowed to enjoy his honours in peace, for now the far-famed Sandivogius made his appearance at Stuttgard. This was a Polish nobleman, believed to be the greatest alchemist and magician of his age. The two adepts were both wonderfully perplexed, each believing the other possessed of the secret. Muller, to relieve himself from the embarrassment of the presence of his rival, found means to persuade him that the duke intended to put him to the torture, in order to make him confess his secret; upon which Sandivogius ran away from Stuttgard. Muller contrived to have him arrested by the way, and confined in prison; where he almost lost his life by the severities inflicted on him, in order to make him give up his secret to his false brother; for Muller had no doubt of Sandivogius being in possession of the philosopher's stone. Sandivogius at last making his escape, Muller was apprehended, condemned, and executed; being dressed at his execution in a garment covered with leaf gold.

It is astonishing how many persons lost their all in pursuit of this vain science; but the alchemist still persevered, and one generation after another, trode in the same path of folly. The alchemist was seldom induced to give way to disappointment. He again filled alembic and aludel; again tried a new mixture of sulphur, mercury, and salt; again heated his furnace; and every successive change in the appearance of the materials he employed, filled his mind with intense hope, that the object of his study was about to be accomplished. A new attempt is still to be made, and the scene of his delusive efforts only terminated with his life.

ALCOHOL. This term is applied in strictness only to the pure spirit obtainable by distillation and subsequent rectification from all liquids that have undergone vinous fermentation, and from none but such as are susceptible of it. But it is commonly used to signify this spirit more or less imperfectly freed from water, in the state in which it is usually met with in the shops, and in which, as it was first obtained from the juice of the grape, it was long distinguished by the name of spirit of wine. At present it is extracted chiefly from grain or molasses in Europe, and from the juice of the sugar cane in the West Indies; and in the diluted state in which it commonly occurs in trade, constitutes the basis of the several spirituous liquors called brandy, rum, gin, whisky, and cordials, however variously denominated or disguised.

As we are not able to compound alcohol immediately from its ultimate constituents, we have recourse to the process of fermentation, by which its principles are first extricated from the substances in which they were combined, and then united into a new compound; to distillation, by which this new compound, the alcohol, is separated in a state of dilution with water, and contaminated with essential oil; and to rectification, by which it is ultimately freed from these.

It appears to be essential to the fermentation of alcohol, that the fermenting fluid should contain saccharine matter, which is indispensable to that species of fermentation called vinous. In France, where a great deal of wine is made,

particularly at the commencement of the vintage, that is too weak to be a saleable commodity, it is a common practice to subject this wine to distillation, in order to draw off the spirit: and as the essential oil that rises in this process is of a more pleasant flavour than that of malt or molasses, the French brandies are preferred to any other; though even in the flavour of these there is a difference, according to the wine from which they are produced. In the West Indies a spirit is obtained from the juice of the sugar-cane, which is highly impregnated with its essential oil, and well known by the name of *rum*. The distillers in this country use grain, or molasses, whence they distinguish the products by the name of *malt spirits*, and *molasses spirits*. It is said that a very good spirit may be extracted from the husks of gooseberries or currants, after wine has been made from them.

As the process of malting developes the saccharine principle of grain, it would appear to render it fitter for the purpose; though it is the common practice to use about three parts of raw grain with one of malt. For this, two reasons may be assigned: by using raw grain the expense of malting is saved, as well as the duty on malt; and the process of malting requires some nicety of attention; since, if it be carried too far, part of the saccharine matter is lost, and if it be stopped too soon, this matter will not be wholly developed. Besides, if the malt be dried too quickly, or by an unequal heat, the spirit it yields will be less in quantity, and more unpleasant in flavour. Another object of economical consideration is, what grain will afford the most spirit in proportion to its price, as well as the best in quality. Barley appears to produce less spirit than wheat; and if three parts of raw wheat be mixed with one of malted barley, the produce is said to be particularly fine. This is the practice of the distillers in Holland for producing a spirit of the finest quality; but in England they are expressly prohibited from using more than one part of wheat to two of other grain. Rye, however, affords still more spirit than wheat.

The practice with the distillers in Scotland, according to Dr. Ure, is to use one part of malted with from four to nine parts of unmalted grain. This mixture yields an equal quantity of spirit, and at a much cheaper rate than when the former proportions are taken.

Whatever be the grain employed, it may be coarsely ground, and then mixed carefully with a little cold water, to prevent its running into lumps; water about 90° F. may then be added, till it is sufficiently diluted; and, lastly, a sufficient quantity of yeast. The whole is then to be allowed to ferment in a covered vessel, to which, however, the air can have access. Attention must be paid to the temperature; for if it exceed 77° F. the fermentation will be too rapid; if it be below 60°, the fermentation will cease. The mean between these will generally be found most favourable. In this country it is the more common practice to mash the grain as for brewing malt liquors, and boil the wort. But in whichever way it be prepared, or if the *wash*, so the liquor intended for distillation is called, be made from molasses and water, due attention must be paid to the fermentation, that it be continued till the liquor grows fine, and pungent to the taste, which will generally be about the third day, but not so long as to permit the acetous fermentation to commence.

In this state the wash is to be committed to the still, of which, including the head, it should occupy at least three fourths; and distilled with a gentle heat as long as any spirit comes over, which will be till about half the wash is consumed. The more slowly the distillation is conducted, the less will the product be contaminated with essential oil, and the less danger will there be of empyreuma. A great saving of time and fuel, however, may be obtained by making the still very broad and shallow, and contriving a free exit for the steam. Formerly, when the excise was levied on the size of the still

and time of working it, this practice was carried to such a pitch in Scotland, that a still measuring 43 gallons, and containing 16 gallons of wash, has been charged and worked no less than four hundred and eighty times in the space of twenty four hours. This would be incredible, were it not established by unquestionable evidence.

The first product, technically termed *low wine*, is again to be subjected to distillation, the latter portions of what comes over, called *faints*, being set apart to put into the wash still at some future operation. Thus a large portion of the watery part is left behind. This second product, termed *raw spirit*, being distilled again, is called *rectified spirit*. It is calculated, that a hundred gallons of malt or corn wash, will not produce above twenty of spirit, containing 60 parts of alcohol to 50 of water; the same of cider wash, 15 gallons; and of molasses wash, 22 gallons. The most spirituous wines of France, those of Languedoc, Guienne, and Rousillon, yield, according to Chaptal, from 20 to 25 gallons of excellent brandy from 100; but those of Burgundy and Champagne much less. Brisk wines, containing much carbonic acid, from the fermentation having been stopped at an early period, yield the least spirit.

The spirit thus obtained ought to be colourless, and free from any disagreeable flavour; and in this state it is fittest for pharmaceutical purposes, or the extraction of tinctures. But for ordinary sale something more is required. The brandy of France, which is most in esteem here, though perfectly colourless when first made, and often preserved so for use in that country, by being kept in glass or stone bottles, is put into new oak casks for exportation, whence it soon acquires an amber colour, a peculiar flavour, and something like an unctuosity of consistence. As it is not only prized for these qualities, but they are commonly deemed essential to it, the English distiller imitates, by design, these accidental qualities. The most obvious and natural method of doing this, would be by impregnating a pure spirit with the extractive, resinous, and colouring matter of oak shavings; but other modes have been contrived. The dulcified spirit of nitre, as it is called, is commonly used to give the flavour; and catechu, or burnt sugar, to impart the desired colour. A French writer has recommended three ounces and a half of finely powdered charcoal, and four ounces and a half of ground rice, to be digested for a fortnight in a quart of malt spirit.

The finest gin is said to be made in Holland, from a spirit drawn from wheat, mixed with a third or fourth part of malted barley, and twice rectified over juniper berries; but in general, rye meal is used instead of wheat. They pay so much regard to the water employed, that many send vessels to fetch it on purpose from the Meuse; but all use the softest and clearest river water they can get. In England it is the common practice to add oil of turpentine, in the proportion of two ounces to ten gallons of raw spirit, with three handfuls of bay salt, and draw off till the faints begin to rise.

But corn or molasses spirit is flavoured likewise by a variety of aromatics, with or without sugar, to please different palates: all of which are included under the general technical term of *compounds* or *cordials*.

Other articles have been employed, though not generally, for the fabrication of spirit, as carrots and potatoes; and we are lately informed by Professor Proust, that from the fruit of the carrot tree he has obtained good brandy in the proportion of a pint from five pounds of the dried fruit.

The spirits distilled from different fermented liquors differ in their flavour: for peculiar odorous matter, or volatile oils, rise in most cases with the alcohol. The spirit from malt usually has an empyreumatic taste like that of the oil, formed by the distillation of vegetable substances. The best brandies seem to owe their flavour to a peculiar oily matter, formed probably by the action of the tartaric

acid on alcohol; and rum derives its characteristic taste from a principle in the sugar cane. All the common spirits may be deprived of their peculiar flavour by repeatedly digesting them with a mixture of well burnt charcoal and quicklime; they then afford pure alcohol by distillation. The cognac brandies contain vegetable prussic acid, and their flavour may be imitated by adding to a solution of alcohol in water of the same strength, a few drops of the ethereal oil of wine produced during the formation of ether, and a similiar quantity of vegetable prussic acid, procured from laurel leaves or any bitter kernels.

To obtain pure alcohol, different processes have been recommended; but the purest rectified spirit obtained as above described, being that which is least contaminated with foreign matter, should be employed. Rouelle recommends to draw off half the spirit in a water bath; to rectify this twice more, drawing off two-thirds each time; to add water to this alcohol, which will turn it milky by separating the essential oil remaining in it; to distil the spirit from this water; and finally rectify it by one more distillation.

Baume sets apart the first running, when about a fourth is come over, and continues the distillation till he has drawn off about as much more, or till the liquor runs off milky. The last running he puts into the still again, and mixes the first half of what comes over with the preceding first product. This process is again repeated, and all the first products being mixed together, are distilled afresh. When about half the liquor is come over, this is to be set apart as pure alcohol.

Alcohol in this state, however, is not so pure as when, to use the language of the old chemists, it has been *dephlegmated*, or still further freed from water, by means of some alkaline salt. Boerhaave recommended, for this purpose, the muriate of soda, deprived of its water of crystallization by heat, and added hot to the spirit. But the subcarbonate of potash is preferable. About a third of the weight of the alcohol should be added to it in a glass vessel, well shaken, and then suffered to subside. The salt will be moistened by the water absorbed from the alcohol; which being decanted, more of the salt is to be added, and this is to be continued till the salt falls dry to the bottom of the vessel. The alcohol in this state will be reddened by a portion of the pure potash, which it will hold in solution, from which it must be freed by distillation in a water bath. Dry muriate of lime may be substituted advantageously for the alkali.

As alcohol is much lighter than water, its specific gravity is adopted as the test of its purity. Fourcroy considers it as rectified to the highest point when its specific gravity is 829, that of water being 1,000; and perhaps this is nearly as far as it can be carried by the process of Rouelle or Baume simply. Mr. Bories found the first measure that came over from twenty of spirit at 836 to be 820, at the temperature of 71° F. Sir Charles Blagden, by the additon of alkali, brought it to 813, at 60° F. Chaussier professes to have reduced it to 798; but he gives 998.35 as the specific gravity of water. Lowitz asserts, that he has obtained it at 791, by adding as much alkali as nearly to absorb the spirit; but the temperature is not indicated. In the shops it is about 835 or 840; according to the London College it should be 815.

It is by no means an easy undertaking to determine the strength or relative value of spirits, even with sufficient accuracy for commercial purposes. The following requisites must be obtained before this can be well done: the specific gravity of a certain number of mixtures of alcohol and water must be taken so near each other, as that the intermediate specific gravities may not perceptibly differ from those deduced from the supposition of a mere mixture of the fluids; the expansions or variations of specific gravity in these mixtures must be determined at different temperatures; some easy

method must be contrived of determining the presence and quantity of saccharine or oleaginous matter which the spirit may hold in solution, and the effect of such solution on the specific gravity; and lastly, the specific gravity of the fluid must be ascertained by a proper floating instrument with a graduated stem, or set of weights; or, which may be more convenient, with both.

The strength of brandies in commerce is judged by the phial, or by burning. The phial proof consists in agitating the spirit in a bottle, and observing the form and magnitude of the bubbles that collect round the edge of the liquor, technically termed the *bead*, which are larger the stronger the spirit. These probably depend on the solution of resinous matter from the cask, which is taken up in greater quantities, the stronger the spirit. It is not difficult, however, to produce this appearance by various simple additions to weak spirit. The proof by burning is also fallacious; because the magnitude of the flame, and quantity of residue, in the same spirit, vary greatly with the form of the vessel it is burned in. If the vessel be kept cool, or suffered to become hot, if it be deeper or shallower, the results will not be the same in each case. It does not follow, however, but that manufacturers and others may in many instances receive considerable information from these signs, in circumstances exactly alike, and in the course of operations wherein it would be inconvenient to recur continually to experiments of specific gravity.

The importance of this object, as well for the purposes of revenue as of commerce, induced the British government to employ Dr. Blagden, now Sir Charles, to institute a very minute and accurate series of experiments. These may be considered as fundamental results; for which reason, I shall give a summary of them in this place, from the Philosophical Transactions for 1790.

The first object to which the experiments were directed was to ascertain the quantity and law resulting from the mutual penetration of water and spirit.

All bodies in general expand by heat; but the quantity of this expansion, as well as the law of its progression, is probably not the same in any two substances. In water and spirit they are remarkably different. The whole expansion of pure spirit from 30° to 100° of Fahrenheit's thermometer is not less than 1-25th of its whole bulk at 30°; whereas that of water, in the same interval, is only 1-145th of its bulk. The laws of their expansion are still more different than the quantities. If the expansion of quicksilver be, as usual, taken for the standard, (our thermometers being constructed with that fluid) the expansion of spirit is, indeed, progressively increasing with respect to that standard, but not much so within the above-mentioned interval; while water kept from freezing to 30°, which may easily be done, will absolutely contract as it is heated for ten or more degrees, that is, to 40° or 42° of the thermometer, and will then begin to expand as its heat is augmented, at first slowly, and afterward gradually more rapidly, so as to observe upon the whole a very increasing progression. Now, mixtures of these two substances will, as may be supposed, approach to the less or the greater of these progressions, according as they are compounded of more spirit or more water, while their total expansion will be greater, according as more spirit enters into their composition; but the exact quantity of the expansion, as well as law of the progression, in all of them, can be determined only by trials. These were, therefore, the two other principal objects to be ascertained by experiment.

The person engaged to make these experiments was Dr. Dollfuss, an ingenious Swiss gentleman, then in London, who had distinguished himself by several publications on chemical subjects. As he could not conveniently get the quantity of spirit he wanted lighter than 825, at 60° F., he had

upon this strength as the standard for alcohol.

These experiments of Dr. Dollfuss were repeated by Mr. Gilpin, clerk of the Royal Society; and as the deductions in this account will be taken chiefly from that last set of experiments, it is proper here to describe minutely the method observed by Mr. Gilpin in his operation. This naturally resolves itself into two parts: the way of making the mixtures, and the way of ascertaining their specific gravity.

1. The mixtures were made by weight, as the only accurate method of fixing the proportions. In fluids of such very unequal expansions by heat as water and alcohol, if measures had been employed, increasing or decreasing in regular proportions to each other, the proportions of the masses would have been sensibly irregular: now the latter was the object in view, namely, to determine the real quantity of spirit in any given mixture, abstracting the consideration of its temperature. Besides, if the proportions had been taken by measure, a different mixture should have been made at every different degree of heat. But the principal consideration was, that with a very nice balance, such as was employed on this occasion, quantities can be determined to much greater exactness by weight than by any practicable way of measurement. The proportions were, therefore, always taken by weight. A phial being provided of such a size as that it should be nearly full with the mixture, was made perfectly clean and dry, and being counterpoised, as much of the pure spirit as appeared necessary was poured into it. The weight of this spirit was then ascertained, and the weight of distilled water required to make a mixture of the intended proportions was calculated. This quantity of water was then added, with all the necessary care, the last portions being put in by means of a well-known instrument, which is composed of a small dish, terminating in a tube, drawn to a fine point: the top of the dish being covered with the thumb, the liquor in it is prevented from running out through the tube by the pressure of the atmosphere, but instantly begins to issue by drops, or a very small stream, upon raising the thumb. Water being thus introduced into the phial, till it exactly counterpoised the weight, which having been previously computed, was put into the opposite scale, the phial was shaken, and then well stopped with its glass stopple, over which leather was tied very tight, to prevent evaporation. No mixture was used till it had remained in the phial at least a month, for the full penetration to have taken place; and it was always well shaken before it was poured out to have its specific gravity tried.

2. There are two common methods of taking the specific gravity of fluids; one, by finding the weight which a solid body loses by being immersed in them; the other, by filling a convenient vessel with them, and ascertaining the increase of weight it acquires. In both cases a standard must have been previously taken, which is usually distilled water; namely, in the first method, by finding the weight lost by the solid body in the water; and in the second method, the weight of the vessel filled with water. The latter was preferred, for the following reasons:—

When a ball of glass, which is the properest kind of solid body, is weighed in any spirituous or watery fluid, the adhesion of the fluid occasions some inaccuracy, and renders the balance comparatively sluggish. To what degree this effect proceeds is uncertain; but from some experiments made by Mr. Gilpin, with that view, it appears to be very sensible. Moreover, in this method a large surface must be exposed to the air during the operation of weighing, which, especially in the higher temperatures, would give occasion to such an evaporation as to alter essentially the strength of the mixture. It seemed, also, as if the temperature of the fluid under trial could be determined more ex-

actly in the method of filling a vessel, than in the other: for the fluid cannot well be stirred while the ball to be weighed remains immersed in it; and as some time must necessarily be spent in the weighing, the change of heat which takes place during that period, will be unequal through the mass, and may occasion a sensible error. It is true, on the other hand, that in the method of filling a vessel, the temperature could not be ascertained with the utmost precision, because the neck of the vessel employed, containing about ten grains, was filled up to the mark with spirit not exactly of the same temperature, as will be explained presently: but this error, it is supposed, would by no means equal the other, and the utmost quantity of it may be estimated very nearly. Finally, it was much easier to bring the fluid to any given temperature when it was in a vessel to be weighed, than when it was to have a solid body weighed in it; because in the former case, the quantity was smaller, and the vessel containing it more manageable, being readily heated with the hand or warm water, and cooled with cold water: and the very circumstance, that so much of the fluid was not required, proved a material convenience. The particular disadvantage in the method of weighing in a vessel, is the difficulty of filling it with extreme accuracy; but when the vessel is judiciously and neatly marked, the error of filling will, with due care, be exceedingly minute. By several repetitions of the same experiments, Mr. Gilpin seemed to bring it within the 1-15,000th part of the whole weight.

The above mentioned considerations induced Dr. Blagden, as well as the gentlemen employed in the experiments, to give the preference to weighing the fluid itself; and that was accordingly the method practised both by Dr. Dollfuss and Mr. Gilpin in their operations.

The vessel chosen as most convenient for the purpose, was a hollow glass ball, terminating in a neck of small bore. That which Dr. Dollfuss used, held 5,800 grains of distilled water; but as the balance was so extremely accurate, it was thought expedient, upon Mr. Gilpin's repetition of the experiments, to use one of only 2,965 grains capacity, as admitting the heat of any fluid contained in it to be more nicely determined. The ball of this vessel, which may be called the weighing bottle, measured about 2.8 inches in diameter, and was spherical, except a slight flattening on the part opposite to the neck, which served as a bottom for it to stand upon. Its neck was formed of a portion of a barometer tube, .25 of an inch in bore, and about 1½ inch long; it was perfectly cylindrical, and, on its outside, very near the middle of its length, a fine circle or ring was cut round it with a diamond, as the mark to which it was to be filled with the liquor. This mark was made by fixing the bottle in a lathe, and turning it round with great care, in contact with the diamond. The glass of this bottle was not very thick; it weighed 916 grains, and with its silver cap 936.

When the specific gravity of any liquor was to be taken by means of this bottle, the liquor was first brought nearly to the required temperature, and the bottle was filled with it up to the beginning of the neck only, that there might be room for shaking it. A very fine and sensible thermometer was then passed through the neck of the bottle into the contained liquor, which showed whether it was above or below the intended temperature. In the former case the bottle was brought into colder air, or even plunged for a moment into cold water; the thermometer in the mean time, being frequently put into the contained liquor, till it was found to sink to the right point. In like manner, when the liquor was too cold, the bottle was brought into warmer air, immersed in warm water, or more commonly held between the hands, till upon repeated trials with the thermometer, the just temperature was found. It will be understood, that during the course of this heating or cooling, the bottle was very fre-

quently shaken between each immersion of the thermometer; and the top of the neck was kept covered, either with the finger, or a silver cap made on purpose, as constantly as possible. Hot water was used to raise the temperature only in heats of 80° and upwards, inferior heats being obtained by applying the hands to the bottle: when the hot water was employed, the ball of the bottle was plunged into it, and again quickly lifted out, with the necessary shaking interposed, as often as was necessary for communicating the required heat to the liquor; but care was taken to wipe the bottle dry after each immersion, before it was shaken, lest any adhering moisture might, by accident, get into it. The liquor having by these means been brought to the desired temperature, the next operation was to fill up the bottle exactly to the mark upon the neck, which was done with some of the same liquor, by means of a glass funnel with a very small bore. Mr. Gilpin endeavoured to get that portion of the liquor which was employed for this purpose, pretty nearly to the temperature of the liquor contained in the bottle; but as the whole quantity to be added never exceeded ten grains, a difference of ten degrees in the heat of that small quantity, which is more than it ever amounted to, would have occasioned an error of only 1 30th of a degree in the temperature of the mass. Enough of the liquor was put in to fill the neck rather above the mark, and the superfluous quantity was then absorbed to great nicety, by bringing into contact with it the fine point of a small roll of blotting paper. As the surface of the liquor in the neck would be always concave, the bottom or centre of this concavity was the part made to coincide with the mark round the glass; and in viewing it, care was taken, that the near and opposite sides of the mark should appear exactly in the same line, by which means all parallax was avoided. A silver cap, which fitted tight, was then put upon the neck, to prevent evaporation; and the whole apparatus was in that state laid in the scale of the balance, to be weighed with all the exactness possible.

The spirit employed by Mr. Gilpin was furnished to him by Dr. Dollfuss, under whose inspection it had been rectified from rum supplied by government. Its specific gravity, at 60 degrees of heat, was .82514. It was first weighed pure, in the above mentioned bottle, at every five degrees of heat, from 30 to 100 inclusively. Then mixtures were formed of it, and distilled water, in every proportion, from 1 20th of the water to equal parts of water and spirit; the quantity of water added being successively augmented, in the proportion of five grains to one hundred of the spirit; and these mixtures were also weighed in the bottle, like the pure spirit, at every five degrees of heat. The numbers hence resulting are delivered in the following table; where the first column shows the degrees of heat; the second gives the weight of the pure spirit contained in the bottle at those different degrees; the third gives the weight of a mixture in the proportions of 100 parts by weight of that spirit to 5 of water, and so on successively till the water is to the spirit as 100 to 5. They are the mean of three several experiments at least, as Mr. Gilpin always filled and weighed the bottle over again that number of times, if not oftener. The heat was taken at the even degree, as shown by the thermometer, without any allowance in the first instance, because the coincidence of the mercury with a division can be perceived more accurately than any fraction can be estimated; and the errors of the thermometers, if any, it was supposed would be less upon the grand divisions of 5 degrees than in any others. It must be observed, that Mr. Gilpin used the same mixture throughout all the different temperatures, heating it up from 30° to 100°; hence some small error in its strength may have been occasioned in the higher degrees, by more spirit evaporating than water: but this, it is believed, must have been trifling, and greater inconvenience would probably have

resulted from interposing a fresh mixture.

The precise specific gravity of the pure spirit employed was .82514; but to avoid an inconvenient fraction, it is taken, in constructing the table of specific gravities, as .825 only, a proportional deduction being made from all the other numbers. Thus the following table gives the true specific gravity at the different degrees of heat, of a pure rectified spirit, the specific gravity of which at 60° is .825, together with the specific gravities of different mixtures of it with water, at those different temperatures.

Real Specific Gravities at the different Temperatures.

Heat.	The pure spirit.	100 grains of spirit to 5 gr. of water	100 grains of spirit to 10 gr. of water	100 grains of spirit to 15 gr. of water	100 grains of spirit to 20 gr. of water	100 grains of spirit to 25 gr. of water	100 grains of spirit to 30 gr. of water	100 grains of spirit to 35 gr. of water	100 grains of spirit to 40 gr. of water	100 grains of spirit to 45 gr. of water	100 grains of spirit to 50 gr. of water
30°	·83896	·84905	·85957	·86825	·87585	·88282	·88921	·89511	·90054	·90558	·91023
35	83672	84769	85729	86587	87357	88050	88701	89294	89839	90345	90811
40	83445	84539	85507	86361	87134	87838	88481	89073	89617	90127	90596
45	83214	84310	85277	86131	86905	87613	88255	88849	89396	89909	90380
50	82977	84076	85042	85902	86676	87384	88030	88626	89174	89684	90160
55	82736	83844	84802	85664	86441	87150	87796	88393	88945	89458	89933
60	82500	83599	84568	85430	86208	86918	87569	88169	88720	89232	89707
65	82262	83362	84334	85193	85976	86686	87337	87938	88490	89006	89479
70	82023	83124	84092	84951	85736	86451	87105	87705	88254	88773	89252
75	81780	82878	83851	84710	85496	86212	86864	87466	88018	88538	89018
80	81530	82631	83603	84467	85248	85966	86622	87228	87776	88301	88781
85	81291	82396	83371	84243	85036	85757	86411	87021	87590	88120	88609
90	81044	82150	83126	84001	84797	85518	86172	86787	87360	87889	88376
95	80794	81900	82877	83753	84550	85272	85928	86542	87114	87654	88146
100	80548	81657	82639	83513	84038	85031	85688	86302	86879	87421	87915

Heat.	100 grains of spirit to 55 gr. of water	100 grains of spirit to 60 gr. of water	100 grains of spirit to 65 gr. of water	100 grains of spirit to 70 gr. of water	100 grains of spirit to 75 gr. of water	100 grains of spirit to 80 gr. of water	100 grains of spirit to 85 gr. of water	100 grains of spirit to 90 gr. of water	100 grains of spirit to 95 gr. of water	100 grains of spirit to 100 gr. of water
30°	·91449	·91847	·92217	·92563	·92889	·93191	·93474	·93741	·94001	·94222
35	91241	91640	92009	92355	92680	92986	93274	93541	93790	94025
40	91026	91428	91799	92151	92476	92783	93072	93341	93592	93827
45	90812	91211	91584	91937	92264	92570	92859	93131	93382	93621
50	90596	90997	91370	91723	92051	92358	92647	92919	93177	93419
55	90367	90768	91144	91502	91837	92145	92436	92707	92963	93208
60	90144	90549	90927	91287	91622	91933	92225	92499	92758	93002
65	89920	90328	90707	91066	91400	91715	92010	92283	92546	92794
70	89695	90104	90484	90847	91181	91493	91793	92069	92333	92580
75	89464	89872	90252	90617	90952	91270	91569	91849	92111	92364
80	89225	89639	90021	90385	90723	91046	91340	91622	91891	92142
85	89013	89460	89843	90209	90558	90882	91186	91465	91729	91969
90	88817	89230	89617	89988	90342	90668	90967	91248	91511	91751
95	88588	89003	89390	89763	90119	90443	90747	91020	91290	91531
100	88357	88769	89158	89536	89889	90215	90522	90805	91066	91310

Heat.	95 grains of spirit to 100 gr. of water	90 grains of spirit to 100 gr. of water	85 grains of spirit to 100 gr. of water	80 grains of spirit to 100 gr. of water	75 grains of spirit to 100 gr. of water	70 grains of spirit to 100 gr. of water	65 grains of spirit to 100 gr. of water	60 grains of spirit to 100 gr. of water	55 grains of spirit to 100 gr. of water	50 grains of spirit to 100 gr. of water
30°	·94147	·94675	·94920	·95173	·95429	·95681	·95944	·96209	·96470	·96719
35	94249	94484	94734	94988	95246	95502	95772	96048	96315	96579
40	94058	94295	94547	94802	95060	95328	95602	95879	96159	96434
45	93860	94096	94348	94605	94871	95143	95423	95705	95993	96280
50	93658	93897	94149	94414	94683	94958	95243	95534	95831	96126
55	93452	93696	93948	94213	94486	94767	95057	95357	95662	95966
60	93247	93493	93749	94018	94296	94579	94876	95181	95493	95804
65	93040	93285	93546	93822	94099	94388	94689	95000	95318	95635
70	92828	93076	93337	93616	93898	94193	94500	94813	95139	95469
75	92613	92865	93132	93413	93695	93989	94301	94623	94957	95292
80	92393	92646	92917	93201	93488	93785	94102	94431	94768	95111

Heat.	45 grains of spirit to 100 gr. of water	40 grains of spirit to 100 gr. of water	35 grains of spirit to 100 gr. of water	30 grains of spirit to 100 gr. of water	25 grains of spirit to 100 gr. of water	20 grains of spirit to 100 gr. of water	15 grains of spirit to 100 gr. of water	10 grains of spirit to 100 gr. of water	5 grains of spirit to 100 gr. of water
30°	·96967	·97200	·97418	·97635	·97860	·98108	·98412	·98804	·99334
35	96840	97086	97319	97556	97801	98076	98397	98804	99344
40	96706	96967	97220	97472	97737	98033	98373	98795	99345
45	96563	96840	97110	97384	97666	97980	98338	98774	99338
50	96420	96708	96995	97284	97589	97920	98293	98745	99316
55	96272	96575	96877	97181	97500	97847	98230	98702	99284
60	96122	96437	96752	97074	97410	97771	98176	98654	99244
65	95962	96288	96620	96959	97309	97688	98106	98594	99194
70	95802	96143	96484	96836	97203	97596	98028	98527	99134
75	95638	95987	96344	96708	97086	97495	97943	98454	99066
80	95467	95826	96192	96568	96963	97385	97845	98367	98991

From this table, when the specific gravity of any spirituous liquor is ascertained, it will be easy to find the quantity of rectified spirit of the above-mentioned standard, contained in any given quantity of it, either by weight or measure.

Dr. Blagden concludes this part of the report with observing, that as the experiments were made with pure spirit and water, if any extraneous substances are contained in the liquor to be tried, the specific gravity in the tables will not give exactly the proportions of water and spirit in it. The substances likely to be found in spirituous liquors, where no fraud is suspected, are essential oils, sometimes empyreumatic, mucilaginous or extractive matter, and perhaps some saccharine matter. The effect of these, in the course of trade, seems to be hardly such as would be worth the cognizance of the excise, nor could it easily be reduced to

certain rules. Essential and empyreumatic oils are nearly of the same specific gravity as spirit, in general rather lighter, and therefore, notwithstanding the mutual penetration, will probably make little change in the specific gravity of any spirituous liquour in which they are dissolved. The other substances are all heavier than spirit; the specific gravity of common gum being 1.482, and of sugar 1.606, according to the tables of M. Brisson. The effect of them therefore will be to make spirituous liquors appear less strong than they really are. An idea was once entertained of endeavouring to determine this matter with some precision; and accordingly Dr. Dollfuss evaporated 1000 grains of brandy, and the same quantity of rum, to dryness; the former left a residuum of 40 grains, the latter only of 8½ grains. The 40 grains of residuum from the brandy, dissolved again in a mixture of 100 of spirit, with 50 of water, increased its specific gravity .00041; hence the effect of this extraneous matter upon the specific gravity of the brandy containing it, would be to increase the fifth decimal by six nearly, equal to what would indicate in the above mentioned mixture, about one seventh of a grain of water more than the truth, to 100 of spirit; a quantity much too minute for the consideration of government.

Very little practice will enable to ascertain, with the help of the above tables, the quantity of spirit in any mixture. It is necessary first to ascertain the specific gravity, according to the usual rules for that purpose, and then by the thermometer observe what is the temperature. Let us suppose that the specific gravity is found to be 920, and the temperature 50° of Fahrenheit, by searching in the table, in the lines horizontal with 50°, we will soon find ·92051, which is directly under 100 grains of spirit to 75 grains of water. In the supposed mixture, therefore, there are four parts spirit and three water. Let us suppose the specific gravity to be 945, and the temperature 70°, by searching in the horizontal lines opposite to 70°, we find ·91500 directly under 65 grains of spirit to 100 of water.

In taking the excise of liquors, use is made of an instrument called the hydrometer.

The most remarkable characteristic property of alcohol, is its solubility or combination in all proportions with water; a property possessed by no other combustible substance, except the acetic spirit obtained by distilling the dry acetates. When it is burned in a chimney which communicates with the worm-pipe of a distilling apparatus, the product, which is condensed, is found to consist of water, which exceeds the spirit in weight about one-eighth part; or more accurately, 100 parts of alcohol, by combustion, yield 136 of water. If alcohol be burned in closed vessels with vital air, the product is found to be water and carbonic acid. Whence it is inferred that alcohol consists of hydrogen, united either to carbonic acid or its acidifiable base; and that the oxygen uniting on the one part with the hydrogen, forms water; and on the other with the base of the carbonic acid, forms that acid.

A considerable number of the uses of this fluid as a menstruum, will pass under our observation in the various articles of this work. The mutual action between alcohol and acids produces a light, volatile, and inflammable oil, called ether. Pure alkalis unite with spirit of wine, and form alkaline tinctures. Few of the neutral salts unite with this fluid, except such as contain ammonia. The carbonated fixed alkalis are not soluble in it. From the strong attraction which exists between alcohol and water, it unites with this last in saline solutions, and in most cases precipitates the salt. This is a pleasing experiment, which never fails to surprise those who are unacquainted with chemical effects. If, for example, a saturated solution of nitre in water be taken, and an equal quantity of strong spirit of wine be poured upon it, the mixture will constitute a weaker spirit, which is incapable of holding the nitre in solution; it there-

fore falls to the bottom instantly, in the form of minute crystals.

The degrees of solubility of many neutral salts in alcohol have been ascertained by experiments made by Macquer, of which an account is published in the Memoirs of the Turin Academy. The alcohol he employed was carefully freed from superabundant water by repeated rectifications, without addition of any intermediate substance. The salts employed in his experiments were previously deprived of their water of crystallization by a careful drying. He poured into a matrass, upon each of the salts thus prepared, half an ounce of his alcohol, and set the matrass in a sand-bath. When the spirit began to boil, he filtrated it while it was hot, and left it to cool, that he might observe the crystallizations which took place. He then evaporated the spirit, and weighed the saline residuums. He repeated these experiments a second time, with this difference, that instead of evaporating the spirit in which the salt had been digested, he set fire to it in order to examine the phenomena which its flame might exhibit. The principal results of his experiments are subjoined.

Quantity of grains.	*Salts soluble in 200 grains of spirit.*	*Peculiar phenomena of the flame.*
4	Nitrate of potash	Flame larger, higher, more ardent, yellow, and luminous.
5	Muriate of potash	Large, ardent, yellow, & luminous.
0	Sulphate of soda	Considerably red.
15	Nitrate of soda	Yellow, luminous, detonating.
0	Muriate of soda	Larger, more ardent, and reddish.
0	Sulphate of ammonia	None.
108	Nitrate of ammonia	Whiter, more luminous.
24	Muriate of ammonia	None.
288	Nitrate of lime	Larger, more luminous, red, and decrepitating.
288	Muriate of lime	Like that of the calcareous nitre.
84	Nitrate of silver	None.
204	Muriate of mercury	Large, yellow, luminous, and decrepitating.
4	Nitrate of iron	Red and decrepitating.
36	Muriate of iron	More white, luminous, & sparkling.
48	Nitrate of copper	More white, luminous, and green, much smoke. The saline residuum became black and burnt.
48	Muriate of copper	Fine green, white, and red fulgurations.

Macquer accompanies the relation of his experiments with many judicious reflections, not easily capable of abridgement.

Alcohol is remarkable for its resistance to freezing under any degree to which in any climate it may be naturally subjected. In Russia or in the Hudson's bay territory a cask of spirits has been exposed to severe frosts, and whilst the water with which it was combined was reduced to ice, the alcohol was not congealed, but was found in the centre, and in hillows within the ice. Alcohol, of specific gravity .825, has been exposed to an artificial cold of 91° below zero, and has still preserved its liquid form; but at a greater degree of cold at 110° below zero, spirit of a still greater strength has been congealed.

Alcohol of .825 boils at 176°.

In wine there is a large portion of alcohol, as has been clearly ascertained by the experiments of M. Gay Lussac. It was formerly doubted by some chemists, who supposed that the alcohol obtained from wine was generated and evolved in the process of distillation.

If sulphur in sublimation meet with the vapour of alcohol, a very small portion combines with it, which communicates a hydro-sul-

phurous smell to the fluid. The increased surface of the two substances appears to favour the combination. It had been supposed, that this was the only way in which they could be united; but M. Favre has lately asserted, that, having digested two drams of flowers of sulphur in an ounce of alcohol, over a gentle fire not sufficient to make it boil, for twelve hours, he obtained a solution that gave twenty three grains of precipitate. A similar mixture left to stand for a month in a place exposed to the solar rays, afforded sixteen grains of precipitate; and another, from which the light was excluded, gave thirteen grains. If alcohol be boiled with one-fourth of its weight of sulphur for an hour, and filtered hot, a small quantity of minute crystals will be deposited on cooling; and the clear fluid will assume an opaline hue on being diluted with an equal quantity of water, in which state it will pass the filter, nor will any sediment be deposited for several hours. The alcohol used in the last-mentioned experiment did not exceed .840.

Phosphorus is sparingly soluble in alcohol, but in greater quantity by heat than in cold. The addition of water to this solution affords an opaque milky fluid, which gradually becomes clear by the subsidence of the phosphorus.

Earths seem to have scarcely any action upon alcohol. Quicklime, however, produces some alteration in this fluid, by changing its flavour and rendering it of a yellow colour. A small portion is probably taken up.

Soaps are dissolved with great facility in alcohol, with which they combine more readily than with water. None of the metals, or their oxides, are acted upon by this fluid. Resins, essential oils, camphor, bitumen, and various other substances, are dissolved with great facility in alcohol, from which they may be precipitated by the addition of water. From its property of dissolving resins, it becomes the menstruum of one class of varnishes.

Camphor is not only extremely soluble in alcohol, but assists the solution of resins in it. Fixed oils, when rendered drying by metallic oxides, are soluble in it, as well as when combined with alkalis.

Wax, spermaceti, biliary calculi, urea, and all the animal substances of a resinous nature, are soluble in alcohol; but it curdles milk, coagulates albumen, and hardens the muscular fibre and coagulum of the blood.

The uses of alcohol are various. As a solvent of resinous substances and essential oils, it is employed both in pharmacy and by the perfumer. When diluted with an equal quantity of water, constituting what is called proof spirit, it is used for extracting tinctures from vegetable and other substances, the alcohol dissolving the resinous parts, and the water the gummy. From giving a steady heat without smoke when burnt in a lamp, it was formerly much employed to keep water boiling on the tea-table. In thermometers for measuring great degrees of cold, it is preferable to mercury, as we cannot bring it to freeze. It is in common use for preserving many anatomical preparations, and certain subjects of natural history; but to some it is injurious, the molluscæ for instance, the calcareous covering of which it in time corrodes. It is of considerable use too in chemical analysis, as appears under the different articles to which it is applicable.

From the great expansive power of alcohol it has been made a question, whether it might not be applied with advantage in the working of steam-engines. From a series of experiments made by Betancourt, it appears, that the steam of alcohol has, in all cases of equal temperature, more than double the force of that of water; and that the steam of alcohol at 174° F. is equal to that of water at 212°: thus there is a considerable diminution of the consumption of fuel, and where this is so expensive as to be an object of great importance, by contriving the machinery so as to prevent the alcohol from being lost, it may possibly at some future time be used with advantage, if some other fluid of great expansive

power, and inferior price, be not found more economical.

It was observed at the beginning of this article, that alcohol might be decomposed by transmission through a red-hot tube: it is also decomposable by the strong acids, and thus affords that remarkable product, ETHER and OLEUM VINI.

ALE, OR BEER, is a beverage obtained from grain, and chiefly from barley, which must first be made into *Malt*.

Beer is the wine of grain. Malt is usually made of barley. The grain is steeped for two or three days in water until it swells, becomes somewhat tender, and tinges the water of a bright reddish brown colour. The water being then drained away, the barley is spread about two feet thick upon a floor, where it heats spontaneously, and begins to grow, by first shooting out the radicle. In this state the germination is stopped by spreading it thinner, and turning it over for two days; after which it is again made into a heap, and suffered to become sensibly hot, which usually happens in little more than a day. Lastly, it is conveyed to the kiln, where, by a gradual and low heat, it is rendered dry and crisp. This is malt; and its qualities differ according as it is more or less soaked, drained, germinated, dried, and baked. In this, as in other manufactories, the intelligent operators often make a mystery of their processes from views of profit; and others pretend to peculiar secrets who really possess none.

Indian corn, and probably all large grain, requires to be suffered to grow into the blade, as well as root, before it is fit to be made into malt. For this purpose it is buried about two or three inches deep in the ground, and covered with loose earth; and in ten or twelve days it springs up. In this state it is taken up and washed, or fanned, to clear it from its dirt; and then dried in the kiln for use.

The colour of the malt not only affects the colour of the liquor brewed from it; but, in consequence of the chemical operation, of the heat applied, on the principles that are developed in the grain during the process of malting, materially alters the quality of the beer, especially with regard to the properties of becoming fit for drinking and growing fine.

Beer is made from malt previously ground, or cut to pieces by a mill. This is placed in a tun, or tub with a false bottom; hot water is poured upon it, and the whole stirred about with a proper instrument. The temperature of the water in this operation, called mashing, must not be equal to boiling; for, in that case, the malt would be converted into a paste, from which the impregnated water could not be separated. This is called setting. After the infusion has remained for some time upon the malt, it is drawn off, and is then distinguished by the name of sweet wort. By one or more subsequent infusions of water, a quantity of weaker wort is made, which is either added to the foregoing, or kept apart, according to the intention of the operator. The wort is then boiled with hops, which gives it an aromatic bitter taste, and is supposed to render it less liable to be spoiled in keeping; after which it is cooled in shallow vessels, and suffered to ferment, with the addition of a proper quantity of yeast. The fermented liquor is beer; and differs greatly in its quality, according to the nature of the grain, the malting, the mashing, the quantity and kind of the hops and the yeast, the purity or admixtures of the water made use of, the temperature and vicissitudes of the weather, &c.

Beside the various qualities of malt liquors of a similar kind, there are certain leading features by which they are distinguished, and classed under different names, and to produce which, different modes of management must be pursued. The principal distinctions are into beer, properly so called; ale; table or small beer; and porter, which is commonly termed beer in London. Beer is a strong, fine, and thin liquor; the greater part of the mucilage having been separated by boiling the wort longer than for ale, and carrying the fermentation farther, so as to convert the sac-

charine matter into alcohol. Ale is of a more sirupy consistence, and sweeter taste; more of the mucilage being retained in it, and the fermentation not having been carried so far as to decompose all the sugar. Small beer, as its name implies, is a weaker liquor; and is made, either by adding a large portion of water to the malt, or by mashing with a fresh quantity of water what is left after the beer or ale wort is drawn off. Porter was probably made originally from very high dried malt; but it is said that its peculiar flavour cannot be imparted by malt and hops alone.

According to experiments of Mr. Brande, the following is the proportion of alcohol obtained in analysing 100 parts of different kinds of ale or beer.

Burton ale	8.88
Edinburgh ale . . .	6.20
Dorchester ale . . .	5.56
Brown stout	6.80
London porter . . .	4.20
London small porter .	1.28

The proportion of alcohol found in different kinds of wine or beer is, however, not a criterion from which to decide on the comparative advantage to be derived from drinking them.

By the law, as it at present stands, all other articles are prohibited in making beer except malt and hops. The hop plant is, however, a very powerful narcotic, and as such is admitted into the pharmacopœia; and there are other articles, such as gentian root, which might be employed, and frequently are so, to impart a bitter flavour to the beer, which are decidedly innocent, and the infusions of which are prescribed by physicians, to invigorate the stomach and promote digestion. The chief object of the legislature in requiring exclusively hops to be employed, seems, therefore, to be for the purpose of obtaining the large revenue derived from that article.

In times of scarcity of grain permission has been given to employ sugar in breweries in lieu of malt, and there can be no reason why it should not be used, except for the purpose of favouring the agricultural interest at home, and to encourage the produce of a large quantity of grain, which in a time of scarcity may be employed more immediately for food. There have been many articles, however, used in the breweries, which there is just reason to believe to be injurious to the human constitution, and against which the penalties of law are properly directed. So early as the time of Queen Anne statutes were enacted for this purpose. Coculus indicus and nux vomica have decidedly poisonous qualities. Amongst the articles seized at different breweries, and at the laboratories of different brewers' druggists, as appears in evidence given to the Committee of the House of Commons were, coculus indicus, multum (an extract of coculus) colouring, honey, hartshorn shavings, Spanish juice, mixed drugs, ginger, orange powder, liquorice, quassia, grains of Paradise, carraway seeds, copperas, and capsicum. Some of these articles are employed to give a pungency and flavour to weak and bad beer. Sulphuric acid is said to be used to give new beer the taste of beer eighteen months old. Sulphate of iron, alum, and salt are added by the publicans, under the name of beer heading, to impart a frothing property to the beer when poured from one vessel to another. Molasses and extract of gentian, are added for the same purpose.

ALEMBIC, is a small still of a very simple construction, employed in chemical researches, for the purpose of separating volatile products, by first raising them by heat, and then condensing them into a liquid state by cold.

The alembic is used for distillation, when the products are too volatile to admit of the use of the last mentioned apparatus. The alembic consists of a body *a*, to which is adapted a head *b*. The head is of a conical figure, and has its external circumference or base depressed lower than its neck, so that the vapours which rise, and are condensed against its sides, run down into the circular channel formed by its depressed part, from whence they are conveyed by the

nose or beak *c*, into the receiver *d*. This instrument is less simple than the retort, which certainly may be used for the most volatile products, if care be taken to apply a gentle heat on such occasions. But the alembic has its conveniences. In particular the residues of distillations may be easily cleared out of the body *a*; and in experiments of sublimation, the head is very convenient to receive the dry products, while the more volatile and elastic parts pass over into the receiver.

ALEMBROTH SALT. Corrosive muriate of mercury is rendered much more soluble in water, by the addition of muriate of ammonia. From this solution crystals are separated by cooling, which were called sal-alembroth by the earlier chemists, and appear to consist of ammonia, muriatic acid, and mercury.

ALGAROTH, (POWDER OF.)—Among the numerous preparations which the alchemical researches in the nature of antimony have afforded, the powder of algaroth is one. When butter of antimony is thrown into water, it is not totally dissolved; but part of the metallic oxide falls down in the form of a white powder, which is the powder of algaroth. It is violently purgative and emetic in small doses of three or four grains. See ANTIMONY.

ALKAHEST. The pretended universal solvent, or menstruum, of the ancient chemists. Kunckel has very well shown the absurdity of searching for an universal solvent, by asking, "If it dissolve all substances, in what vessels can it be contained?"

ALKALESCENT. Any substance in which alkaline properties are beginning to be developed, or to predominate, is termed alkalescent. The only alkali usually observed to to be produced by spontaneous decomposition is the volatile; and from their tendency to produce this, some species of vegetables, particularly the cruciform, are styled alkalescent, as are some animal substances.

ALKALIS are bodies which have properties the reverse of acids; or which counteract and destroy their power. Thus, an acid will dissolve a metal, but if a sufficient quantity of alkali be mixed with it, that power is destroyed. In the same manner an alkali prevents an acid changing vegetable blue colours to red. 2. In addition to this property, alkalis change blue vegetable colours to green, and yellow vegetable colours to brown. 3. They have an acid taste. 4. They combine with water and alcohol in every proportion. 5. They dissolve animal matter, with which, as well as with oils, they combine and are neutralized. 6. They are attracted to the negative pole of a voltaic arrangement.

The alkalis are distinguished from alkaline earths, which neutralize acids, limes, strontian, magnesia, &c. by their power of acting on vegetable colours, and by being soluble in water after being saturated with carbonic acid.

Potass and soda are found to consist of metallic bases united with oxygen, and are not simple substances, as formerly supposed. Ammonia has been called the volatile alkali. Lithia, a mineral alkali with brucia, strychnia, and many other vegetable alkalis are of late discovery. In the alkalis, as well as in the acids, chemists seem disposed to be too ready in admitting new names without sufficiently rigorous trial of distinct characteristic properties. See the ALKALIS under their respective articles.

ALKALIMETER. An instrument for measuring the quantity of pure alkali contained in a given quantity of the impure soda or potass of commerce.

ALKANET. The alkanet plant is a kind of bugloss, which is a native of the warmer parts of Europe, and cultivated in some of our gardens. The greatest quantities are raised in Germany and France, particularly about Montpelier, whence we are chiefly supplied with the roots. These are of a superior quality to such as are raised in England. This root imparts an elegant deep red colour to pure alcohol, to oils, to wax, and to all unctuous substances. The aqueous tincture is of a dull

brownish colour; as is likewise the spirituous tincture when inspissated to the consistence of an extract. The principal use of alkanet root is, that of colouring oils, unguents, and lip-salves. Wax tinged with it, and applied on warm marble, stains it of a flesh colour, which sinks deep into the stone; as the spirituous tincture gives it a deep red stain.

As the colour of this root is confined to the bark, and the small roots have more bark in proportion to their bulk than the great ones, these also afford most colour.

ALLANITE. This mineral has been so denominated in honour of Mr. Allan, of Edinburgh, a gentleman who has formed a most extensive and splendid collection of minerals, and contributed much to the advancement of mineralogical knowledge in Scotland.

It was found in a rock in West Greenland. It consists of:—

Silica	35.4
Oxide of cerium	33.9
Oxide of iron	25.4
Lime	9.2
Alumina	4.1
Moisture	4.0
	100.0

Its specific gravity is from 3.5 to 3.

ALLOCHROITE. A mineral found in the new mines of Virums, near Drammen in Norway. It consists of silica 35, lime 30.5, oxide of iron 17, alumina 8, carbonate of lime 6, oxide of manganese 3.5.

ALLOPHANE, a mineral found in a bed of ironshot limestone, in the forest of Thuringia.

ALLAY, or ALLOY. Where any precious metal is mixed with another of less value, the assayers call the latter the alloy, and do not in general consider it in any other point of view than as debasing or diminishing the value of the precious metal. Philosophical chemists have availed themselves of this term to distinguish all metallic compounds in general. Thus brass is called an alloy of copper and zinc; bell metal an alloy of copper and tin.

Alloys of gold are usually called gold, although frequently there is a larger portion of copper. The alloys of mercury are usually called amalgams.

Metals unite together in all proportions. By their union they sometimes occupy more bulk than they did when separate, and sometimes less. Sometimes metals united together are very easily fusible; thus even iron becomes very fusible when mixed with gold. Bismuth, lead, and zinc, mixed together, are very easily fusible.

ALLUVIAL FORMATIONS, in geology, signify deposits in the lower grounds of matter, worn down from the neighbouring rocks and mountains. Gravel, loam, clay, and sand, are amongst alluvial deposits.

Ground properly called alluvial, which has been formed from the materials of decomposed rocks, will differ according to the nature of the rocks in different districts.

In mountainous countries, alluvial grounds are principally composed of fragments of rocks, worn by attrition, and of pebbles and sand. Metallic ores, which are very hard or indestructible, are also found in the alluvial depositions of primary and transition rocks. Tin stone, or ore of tin, is found in the form of rounded pebbles, in the banks and sands of the rivulets in Cornwall, and under the sea shore. There can scarcely be a doubt that this ore once formed veins, intersecting mountains that are decomposed and worn down. Small pieces of gold have occasionally been found in a similar situation, which, as well as the gold in the sands of rivers in different parts of the world, had, in all probability, a similar origin. The diamond, and other precious stones, which occur in alluvial depositions, were also probably brought there from decomposed rocks by inundations and mountain torrents.

The alluvial depositions from secondary rocks form beds of sand, clay, and loam, of greater or less thickness. Whether the immeasurable tracts of sand in Africa or Asia, were from the destruction of silicious mountains, or by other processes, cannot be determined.

During volcanic eruptions, an extent of some hundred square miles has frequently been covered with volcanic sand, but this is of a dark grey colour, contains a considerable portion of argillaceous earth, and becomes consolidated by moisture.

ALMONDS. Almonds consist chiefly of an oil of the nature of fat oils, together with farinaceous matter. The oil is so plentiful, and so loosely combined or mixed with the other principles, that it is obtained by simple pressure, and part of it may be squeezed out with the fingers. Five pounds and a half have yielded one pound six ounces of oil by cold expression, and three quarters of a pound more on heating them. There are two kinds of almonds, the sweet and bitter. The bitter almonds yield an oil as tasteless as that of the other, all the bitter matter remaining in the cake after the expression. Great part of the bitter matter dissolves by digestion, both in watery and spirituous liquors; and part arises with both in distillation. Rember obtained from them 1-3d of watery extract, and 3-32ds of spirituous. Bitter almonds are poisonous to birds, and to some animals. A water distilled from them, when made of a certain degree of strength, has been found from experiment to be poisonous to brutes, and there are instances of cordial spirits impregnated with them being poisonous to men. It seems, indeed, that the vegetable principle of bitterness in almonds and the kernels of other fruits, is destructive to animal life, when separated by distillation from the oil and farinaceous matter. The distilled water from laurel leaves appears to be of this nature, and its poisonous effects are well known.

It has been ascertained that the poisonous property in bitter almonds, arises from the hydrocyanic or prussic acid. When an injurious effect is felt in the stomach, an emetic ought immediately to be taken, and after it has operated, a combination of sulphate of iron with carbonate of potass.

Sweet almonds are made into an emulsion by trituration with water, which on standing separates a thick cream floating on the top. The emulsion may be curdled by heat, or the addition of alcohol or acids. The whey contains gum, extractive matter, and sugar, according to Professor Proust; and the curd, when washed and dried, yields oil by expression, and afterward by distillation the same products as cheese. The whey is a good diluent.

ALOES. This is a bitter juice, extracted from the leaves of a plant of the same name. Three sorts of aloes are distinguished in the shops by the names of aloe soccotrina, aloe hepatica, and aloe caballina. The first denomination, which is applied to the purest kind, is taken from the island of Zocotora, the second, or next in quality, is called hepatica, from its liver colour; and the third, caballina, from the use of this species being confined to horses. These kinds of aloes are said to differ only in purity, though, from the difference of their flavours, it is probable that they may be obtained in some instances from different species of the same plant. It is certain, however, that the different kinds are all prepared at Morviedro in Spain, from the same leaves of the common aloe. Deep incisions are made in the leaves, from which the juice is suffered to flow; and this, after decantation from its sediment, and inspissation in the sun, is exposed to sale in leathern bags by the name of soccotrine aloes. An additional quantity of juice is obtained by pressure from the leaves; and this, when decanted from its sediment and dried, is the hepatic aloes. And lastly, a portion of juice is obtained by strong pressure of the leaves, and is mixed with the dregs of the two preceding kinds to form the caballine aloes. The first kind is said to contain much less resin. The principal characters of good aloes are these: it must be glossy, not very black, but brown; when rubbed or cut, of a yellow colour; compact, but easy to break; easily soluble; of an unpleasant peculiar smell, which cannot be described, and an extremely bitter taste.

Aloes appears to be an intimate combination of gummy resinous

matter, so well blended together, that watery or spirituous solvents, separately applied, dissolve the greater part of both. It is not determined whether there be any difference in the medical properties of these solutions. Both are purgative, as is likewise the aloes in substance; and, if used too freely, are apt to prove heating, and produce hemorrhoidal complaints.

ALUDEL. The process of sublimation differs from distillation in the nature of its product, which, instead of becoming condensed in a fluid, assumes the solid state, and the form of the receivers may of course be very different. The receivers for sublimates are of the nature of chimneys, in which the elastic products are condensed, and adhere to their internal surface. It is evident that the head of an alembic will serve very well to receive and condense such sublimates as are not very volatile. The earlier chemists, whose notions of simplicity were not always the most perfect, thought proper to use a number of similar heads, one above the other, communicating in succession by means of a perforation in the superior part of each, which received the neck of the capital immediately above it. These heads differing in no respect from the usual heads of alembics, excepting in their having no nose or beak, and in the other circumstances here mentioned, were called aludels. They are seldom now to be seen in chemical laboratories, because the operations of this art may be performed with greater simplicity of instruments, provided attention be paid to the heat and other circumstances.

ALUM is a salt of the utmost importance in manufactures. It is composed, according to Berzelius, of

Sulphuric acid	34.33
Alumina	10.86
Potash	9.81
Water	45.00
	100.00

Other chemists have analyzed alum, and, although the results have not been the same, there has not been a very material difference.

It is produced, but in a very small quantity, in the native state; and this is mixed with heterogeneous matters. It effloresces in various forms upon ores during calcination, but it seldom occurs crystallized. The greater part of this salt is factitious, being extracted from various minerals called alum ores, such as, 1. Sulphurated clay. This constitutes the purest of all aluminous ores, namely, that of la Tolfa, near Civita Vecchia, in Italy. It is white, compact, and as hard as indurated clay, whence it is called *petra aluminaris*. It is tasteless and mealy; one hundred parts of this ore contain above forty of sulphur and fifty of clay, a small quantity of potash, and a little iron. Bergman says it contains forty-three of sulphur in one hundred, thirty-five of clay, and twenty-two of silicious earth. This ore is first torrefied to acidify the sulphur, which then acts on the clay, and forms the alum.

2. The pyritaceous clay, which is found at Schwemsal, in Saxony, at the depth of ten or twelve feet. It is a black and hard, but brittle substance, consisting of clay, pyrites, and bitumen. It is exposed to the air for two years; by which means the pyrites are decomposed, and the alum is formed. The alum ores of Hesse and Liege are of this kind; but they are first torrefied, which is said to be a disadvantageous method.

3. The schistus aluminaris contains a variable proportion of petroleum and pyrites intimately mixed with it. When the last are in a very large quantity, this ore is rejected as containing too much iron. Professor Bergman very properly suggested, that by adding a proportion of clay, this ore may turn out advantageously for producing alum. But if the petrol be considerable, it must be torrefied. The mines of Becket in Normandy, and those of Whitby in Yorkshire, are of this species.

4. Volcanic aluminous ore. Such is that of Solfaterra near Naples. It is in the form of a white saline earth, after it has effloresced in the air; or else it is in a stony form.

5. Bituminous alum ore is called shale, and is in the form of a schistus, impregnated with so much oily matter, or bitumen, as to be inflammable. It is found in Sweden, and also in the coal mines at Whitehaven, and elsewhere.

Chaptal has fabricated alum on a large scale from its component parts. For this purpose he constructed a chamber 91 feet long, 48 wide, and 31 high in the middle. The walls are of common masonry, lined with a pretty thick coating of plaster. The floor is paved with bricks, bedded in a mixture of raw and burnt clay; and this pavement is covered with another, the joints of which overlap those of the first, and instead of mortar the bricks are joined with a cement of equal parts of pitch, turpentine, and wax, which, after having been boiled till it ceases to swell, is used hot. The roof is of wood, but the beams are very close together, and grooved lengthwise, the intermediate space being filled up by planks fitted into the grooves, so that the whole is put together without a nail. Lastly, the whole of the inside is covered with three or four successive coatings of the cement above-mentioned, the first being laid on as hot as possible; and the outside of the wooden roof was varnished in the same manner. The purest and whitest clay being made into a paste with water, and formed into balls half a foot in diameter, these are calcined in a furnace, broken to pieces, and a stratum of the fragments laid on the floor. A due proportion of sulphur is then ignited in the chamber, in the same manner as for the fabrication of sulphuric acid; and the fragments of burnt clay, imbibing this as it forms, begin after a few days to crack and open, and exhibit an efflorescence of sulphate of alumina. When the earth has completely effloresced, it is taken out of the chamber, exposed for some time in an open shed, that it may be the more intimately penetrated by the acid, and is then lixiviated and crystallized in the usual manner. The cement answers the purpose of lead on this occasion very effectually, and according to M. Chaptal, costs no more than lead would at three farthings a pound.

Curaudau has lately recommended a process for making alum without evaporation. One hundred parts of clay and five of muriate of soda are kneaded into a paste with water, and formed into loaves. With these a reverberatory furnace is filled, and a brisk fire is kept up for two hours. Being powdered, and put into a sound cask, one-fourth of their weight of sulphuric acid is poured over them by degrees, stirring the mixture well at each addition. As soon as the muriatic gas is dissipated, a quantity of water equal to the acid is added, and the mixture stirred as before. When the heat is abated, a little more water is poured in, and this is repeated till eight or ten times as much water as there was acid is added. When the whole has settled, the clear liquor is drawn off into leaden vessels, and a quantity of water equal to this liquor is poured on the sediment. The two liquors being mixed, a solution of potash is added to them, the alkali in which is equal to one fourth of the weight of the sulphuric acid. Sulphate of potash may be used, but twice as much of this as of the alkali is necessary. After a certain time the liquor by cooling affords crystals of alum equal to three times the weight of the acid used. It is refined by dissolving it in the smallest possible quantity of boiling water. The residue may be washed with more water, to be employed in lixiviating a fresh portion of the ingredients.

As the mother water still contains alum, with sulphate of iron very much oxided, it is well adapted to the fabrication of prussian blue. This mode of making alum is particularly advantageous to the manufacturers of prussian blue, as they may calcine their clay at the same time with their animal matters, without additional expense; they will have no need in this case to add potash; and the presence of iron, instead of being injurious, will be very useful. If they wished to make alum for sale, they might use the solution of sulphate of potash arising from the washing

of their prussian blue, instead of water, to dissolve the combination of alumina and sulphuric acid.

The residuums of distillers of aquafortis are applicable to the same purposes, as they contain the alumina and potash requisite, and only require to be reduced to powder, sprinkled with sulphuric acid, and lixiviated with water, in the manner directed above. The mother waters of these alums are also useful in the fabrication of prussian blue. As the residuum of aquafortis contains an over-proportion of potash, it will be found of advantage to add an eighth of its weight of clay calcined as above.

The oldest alum manufactory in Great Britain, is that near Whitby in Yorkshire. It was established by a gentleman who went to Italy, and succeeding in persuading some Italians employed in the Pope's alum works near Civita Vecchia to make their escape, and come to England with him, and notwithstanding the papal sentence of excommunication, the undertaking was attended with good success. An account of this manufactory was published in the 25th volume of Nicholson's Journal.

The only injurious contamination of alum is the sulphate of iron, from which it may be separated by being dissolved in boiling water, and agitated with rods whilst it is cooled. The salt of alum falls to the bottom, and washed two or three times in cold water is drained, and yields a pure alum.

Alum is used in large quantities in many manufactories. When added to tallow, it renders it harder. Printers' cushions, and the blocks used in the calico manufactory, are rubbed with burnt alum to remove any greasiness, which might prevent the ink or colour from sticking. Wood sufficiently soaked in a solution of alum does not easily take fire; and the same is true of paper impregnated with it, which is fitter to keep gunpowder, as it also excludes moisture. Paper impregnated with alum is useful in whitening silver, and silvering brass without heat. Alum mixed in milk helps the separation of its butter. If added in a very small quantity to turbid water, in a few minutes it renders it perfectly limpid, without any bad taste or quality; while the sulphuric acid imparts to it a very sensible acidity, and does not precipitate so soon, or so well, the opaque earthy mixtures that render it turbid, as I have often tried. It is used in making pyrophorus, in tanning, and many other manufactories, particularly in the art of dying, in which it is of the greatest and most important use, by cleansing and opening the pores on the surface of the substance to be dyed, rendering it fit for receiving the colouring particles, (by which the alum is generally decomposed) and at the same time making the colour fixed. Crayons generally consist of the earth of alum, finely powdered, and tinged for the purpose. In medicine it is employed as an astringent.

ALUM EARTH, according to Klaproth, contains charcoal 19·65, silica 40, alumina 16, oxide of iron 6.4, sulphur 2.84 sulphates of lime and potash each 1.5, sulphate of iron 1.8, magnesia and muriate of potash 0.5, and water 10.75.

AMADOU, a variety of boletus igniarius, from which the Germans and French make tinder; for this purpose it is boiled, then dried and beat, and afterwards steeped in a solution of nitre, and dried again. It is used either with a flint and steel, or put into the pyrophorus or fire box, by which it is lighted by the sudden condensation of the air. This plant is found very abundantly in most countries, particularly in the highlands of Scotland, in the trunks of old ash and other trees.

AMALGAM is the combination of mercury with other metals. The most common amalgam is that of mercury and tin, which is put on the back of looking-glasses. An amalgam of mercury and gold leaf is used in water gilding. See Mercury.

AMBER is a hard, brittle, tasteless substance, sometimes perfectly transparent, but mostly semitransparent or opaque, and of a glossy surface; it is found of all colours, but chiefly yellow or orange, and often contains leaves

or insects; its specific gravity is from 1.065 to 1,100; its fracture is even, smooth, and *glossy; it is* capable of a fine polish, and becomes electric by friction; when rubbed or heated, it gives a peculiar agreeable smell, particularly when it melts, that is at 550° of Fahrenheit, but it then loses its transparency; projected on burning coals, it burns with a whitish flame, and a whitish yellow smoke, but gives very little soot, and leaves brownish ashes; it is insoluble in water and alcohol, though the latter, when highly rectified, extracts a reddish colour from it; but it is soluble in the sulphuric acid, which then acquires a reddish purple colour, and is precipitable from it by water; no other acid dissolves it, nor is it soluble in essential or expressed oils, without some decomposition and long digestion; but pure alkali dissolves it. By distillation it affords a small quantity of water, with a little acetous acid, an oil, and a peculiar acid. The oil rises at first colourless; but, as the heat increases, becomes brown, thick, and empyreumatic. The oil may be rectified by successive distillations, or it may be obtained very light and limpid at once, if it be put into a glass alembic with water, as the elder Rouelle directs, and distilled at a heat not greater than 212° Fahr. It requires to be kept in stone bottles, however, to retain this state; for in glass vessels it becomes brown by the action of light.

Amber is met with plentifully in regular mines in some parts of Prussia. The upper surface is composed of sand, under which is a stratum of loam, and under this a bed of wood, partly entire, but chiefly mouldered or changed into a bituminous substance. Under the wood is a stratum of sulphuric or rather aluminous mineral, in which the amber is found. Strong sulphureous exhalations are often perceived in the pits.

Amber has been found in large masses on the sea coast of various countries. Boethius speaks of a piece of amber of the size of a horse, thrown on shore near Peterhead in Scotland, about 1518, and of which *the greater part was consumed in the fire by the ignorant rustics who compared the scent to that of the* frankincense in the churches. In the royal cabinet of Berlin is a piece of amber 18lb. in weight.

The origin of amber is involved in obscurity, but the progress of vegetable chemistry may be expected to throw light on the subject. Dr. Brewster, of Edinburgh, from some experiments concludes, that it is an indurated vegetable juice. Amber may be distinguished from mellite from its being fusible by heat, which is not the case with the latter substance. It is known from copal by spitting and frothing when it burns, whereas the latter falls in drops, if melted on the point of a knife.

Amber is used in making varnishes.

AMBERGRIS is found in the sea, near the coasts of various tropical countries; and has also been taken out of the intestines of the physeter macrocephalus, the spermaceti whale. As it has not been found in any whales but such as are dead or sick, its production is generally supposed to be owing to disease, though some have a little too peremptorily affirmed it to be the cause of the morbid affection. As no large piece has ever been found without a greater or less quantity of the beaks of the sepia octopodia, the common food of the spermaceti whale, interspersed throughout its substance, there can be little doubt of its originating in the intestines of the whale; for if it were occasionally swallowed by it only, and then caused disease, it must much more frequently be found without these, when it is met with floating in the sea, or thrown upon the shore.

Ambergris is found of various sizes, generally in small fragments, but sometimes so large as to weigh near two hundred pounds. When taken from the whale it is not so hard as it becomes afterwards on exposure to the air. Its specific gravity ranges from 780 to 926. If good, it adheres like wax to the edge of a knife with which it is scraped, retains the impression of the teeth or nails, and emits a fat odoriferous liquid on being pene-

trated with a hot needle. It is generally brittle; but, on rubbing it with the nail, it becomes smooth like hard soap. Its colour is either white, black, ash coloured, yellow, or blackish; or it is variegated, namely, grey with black specks, or grey with yellow specks. Its smell is peculiar, and not easy to be counterfeited. At 144° it melts, and at 212° is volatilized in the form of a white vapour. But, on a red-hot coal, it burns, and is entirely dissipated. Water has no action on it; acids, except nitric, act feebly on it; alkalis combine with it, and form a soap; ether and the volatile oils dissolve it; so do the fixed oils, and also ammonia, when assisted by heat; alcohol dissolves a portion of it, and is of great use in analyzing it, by separating its constituent parts. According to Bouillon la Grange, who has given the latest analysis of it, 3820 parts of ambergris consist of adipocere 2016 parts, a resinous substance 1167, benzoic acid 425, and coal 212.

Ambergris has a very remarkable fragrance, and for that reason a solution of it in alcohol is added by the perfumers in very minute quantity to lavender water, tooth powder, hair powder, and wash balls. Its great price, being sold as high as a guinea per ounce, affords a strong temptation to adulterate it, and mixtures of benzoin, labdanum, and meal scented with musk, have been employed for that purpose. Its greasy appearance and its smell, when heated, together with its solubility in alcohol, affords the means of distinguishing it.

AMELYGONITE. A greenish coloured mineral found in granite near Pinig in Saxony.

AMETHYST. The amethyst is a gem of a violet colour, and great brilliancy, said to be as hard as the ruby or sapphire, from which it only differs in colour. This is called the oriental amethyst, and is very rare. When it inclines to the purple or rosy colour, it is more esteemed than when it is nearer to the blue. These amethysts have the same figure, hardness, specific gravity, and other qualities, as the best sapphires or rubies, and come from the same places, particularly from Persia, Arabia, Armenia, and the West Indies. The occidental amethysts are merely coloured crystals or quartz.

AMIANTHUS, OR MOUNTAIN-FLAX. See ASBESTUS.

AMMONIA, called also the volatile alkali, and in the form of gas is well known by the name of hartshorn. It is obtained from sal ammoniac or salt, made on a large scale in Egypt from soot by sublimation, and which is also made abundantly in Europe. It consists of 82.36 nitrogen and 17.64 hydrogen.

Ammoniacal gas extinguishes combustion, and destroys animal life. It is itself, in part, combustible. It has an acrid taste, water rapidly condenses it, and is capable of dissolving one-third of its weight, or 460 times its bulk. Its specific gravity is stated by Sir H. Davy to be 0.590 compared with common air.

When united with water it is called liquid ammonia; the more water the greater is the specific gravity, and by its circumstance its purity may be known. Ten pounds of sal ammoniac will yield about 30 pounds of liquid.

Ammonia has all the properties of an alkali, and has been of essential service in chemical researches. When ammoniacal gas is transmitted through charcoal ignited in a tube of iron, the prussic, or as it is called, the hydrocyanic acid is formed.

Ammonia combines with the acids, and forms neutral salts. The most important of these is the muriate of ammonia, commonly called sal ammonia.

In Egypt, the chief fuel is the dung of camels; and as all animal bodies yield a large portion of ammonia, there is much of it in this dung. Hence the soot is impregnated with sal ammonia. Soot is collected, and put in large glass globes, which are exposed for several days to the heat of a furnace, and then allowed to cool, after which, being broken, the upper part is found to be lined with sal ammoniac. It is said about 6 lbs. are obtained from 26 pounds of soot. In Europe, cylinders of cast iron are charged with bones, horns,

parings of hides and other animal matters, and being exposed to great heat a great quantity of impure carbonate of ammonia distils over. It is made in France by placing in one brick-kiln common salt and sulphuric acid, in another animal matters, and great heat being applied, from the first arises muriatic acid gas, and from the second ammoniacal gas, which being conducted by flues into a third chamber, there unite together and form sal ammoniac. Sal ammoniac may be obtained from coal soot either by sublimation or by lixiviation with water.

AMMONIAC (GUM). This is a gum-resin, being partly soluble in water, and partly in spirits. It is entirely dissolved in ether, nitric acid, and the alkalis. Braconnot, in analysing it, found 70 parts resin, 18.4 gum, 4.4 glutinous matter, 6 water, and 1.2 loss in 100 parts. Its specific gravity is about 1.200. With water it forms a milky solution. It is obtained in small pieces of a yellowish white matter. It has an extremely unpleasant bitter taste. In medicine it is prescribed as an antispasmodic and expectorant. It is given to children when they are recovering from the hooping cough, and partly operates by its unpleasantness in causing them to make an effort to break off the habit of coughing, as they are ordered to take some each time immediately after coughing.

AMNIOTIC ACID. If the liquor amnii of a cow be evaporated to one fourth, crystals will form in it on cooling, which will be found to possess acid properties. These are called the amniotic acid.

AMPHIBOLE, a species of Actynolite.

AMPHIGENE, a species of Vesuvian.

AMYGDALOID is a mineral consisting of green earth, calc spar, steatite, lithomarge, imbedded in fine grained greenstone, sometimes containing the crystals of horn blende.

ANACARDIUM, CASHEW NUT, or MARKING NUT. At one extremity of the fruit of the cashew tree is a flattish kidney-shaped nut, between the rind of which and the thin outer shell is a small quantity of a red, thickish, inflammable, and very caustic liquor. This liquor forms a useful marking ink, as any thing written on linen or cotton with it is of a brown colour, which gradually grows blacker, and is very durable.

ANALCIME, or CUBIC ZEOLITE is a mineral consisting of 58 silica, 18 alumina, 2 lime, 10 soda, 8½ water, and 3½ loss in 100 parts: specific gravity about 2.6. It has been found in Calton hill, Edinburgh, in the isle of Skye, the Ferroe islands. The variety found at Somma, the neighbouring summit to mount Vesuvius, has been called sarcolite from its resemblance to flesh. Analcime is cubic crystals, whose angles are replaced by three planes. It becomes somewhat electrical when heated.

ANALYSIS. Chemical analysis consists of a great variety of operations, performed for the purpose of separating the component parts of bodies. In these operations the most extensive knowledge of such properties of bodies as are already discovered must be applied, in order to produce simplicity of effect, and certainty in the results. Chemical analysis can hardly be executed with success by one who is not in possession of a considerable number of simple substances in a state of great purity, many of which, from their effects, are called reagents. The word analysis is applied by chemists to denote that series of operations, by which the component parts of bodies are determined, whether they be merely separated, or exhibited apart from each other; or whether these distinctive properties be exhibited by causing them to enter into new combinations, without the perceptible intervention of a separate state. The forming of new combinations is called synthesis; and, in the chemical examination of bodies, analysis or separation can scarcely ever be effected, without synthesis taking place at the same time.

As most of the improvements in the science of chemistry consist in bringing the art of analysis nearer to perfection, it is not easy to give any other rule to the learner than

the general one of consulting and remarking the processes of the best chemists, such as Scheele, Bergman, Berthollet, Kirwan, Vauquelin, and Berzelius. The bodies which present themselves more frequently for examination than others, are minerals and mineral waters. In the examination of the former, it was the habit of the earlier chemists to avail themselves of the action of fire, with very few humid processes, which are such as might be performed in the usual temperature of the atmosphere. Modern chemists have improved the process by fire, by a very extensive use of the blow-pipe, and have succeeded in determining the component parts of minerals to great accuracy in the humid way.

Several authors have written on the examination of earths and stones.

The first step in the examination of consistent earths or stones is somewhat different from that of such as are pulverulent. Their specific gravity should first be examined; also their hardness, whether they will strike fire with steel, or can be scratched by the nail, or only by crystal, or stones of still greater hardness; also their texture, perviousness to light, and whether they be manifestly homogeneous or compound species, &c.

2d, In some cases, we should try whether they imbibe water, or whether water can extract any thing from them by ebullition or digestion.

3d, Whether they be soluble in, or effervesce with, acids, before or after pulverization; or whether decomposable by boiling in a strong solution of potash, &c. as gypsums and ponderous spars are.

4th, Whether they detonate with nitre.

5th, Whether they yield the fluor acid by distillation with sulphuric acid, or ammonia by distilling them with potash.

6th, Whether they be fusible *per se* with a blow-pipe, and how they are affected by soda, borax, and microcosmic salt; and whether they decrepitate when gradually heated.

7th, Stones that melt *per se* with the blow-pipe are certainly compound, and contain at least three species of earth, of which the calcareous is probably one; and if they give fire with steel, the silicious is probably another.

The general process prescribed by the celebrated Vauquelin, in the 30th volume of the Annales de Chimie, is the clearest which has yet been offered to the chemical student.

If the mineral be very hard, it is to be ignited in a covered crucible of platinum, and then plunged into cold water, to render it brittle and easily pulverizable. The weight should be noted before and after this operation, in order to see if any volatile matter has been emitted. For the purpose of reducing stones to an impalpable powder, little mortars of highly hardened steel are now made, consisting of a cylindrical case and pestle. A mortar of agate is also used for subsequent levigation. About ten grains of the mineral should be treated at once; and after the whole 100 grains have been reduced in succession to an impalpable powder, they should be weighed, to find what increase may have been derived from the substance of the agate. This addition may be regarded as silica.

Of the ten primary earths, only four are usually met with in minerals, viz. silica, alumina, magnesia, and lime, associated with some metallic oxides, which are commonly iron, manganese, nickel, copper and chronium.

If neither acid nor alkali be expected to be present, the mineral is mixed in a silver crucible, with thrice its weight of pure potash and a little water. Heat is gradually applied to the covered crucible, and is finally raised to redness; at which temperature it ought to be maintained for an hour. If the mass, on inspection, be a perfect glass, silica may be regarded as the chief constituent of the stone; but if the vitrification be very imperfect and the bulk much increased, alumina may be supposed to predominate. A brownish or dull green colour indicates the presence of iron; a bright grass-

green, which is imparted to water, that of manganese; and from a greenish yellow, chromium may be expected. The crucible, still a little hot, being first wiped, is put into a capsule of porcelain or platinum; when, warm distilled water is poured upon the alkaline earthy mass, to detach it from the crucible. Having transferred the whole of it into the capsule, muriatic acid is poured on, and a gentle heat applied, if necessary, to accomplish its solution. If the liquid be of an orange-red colour, we infer the presence of iron; if of a golden-yellow, that of chromium; and if of a purplish-red, that of manganese. The solution is next to be evaporated to dryness, on a sand bath, or over a lamp, taking care so to regulate the heat, that no particles be thrown out. Towards the end of the evaporation, it assumes a gelatinous consistence. At this period it must be stirred frequently with a platinum spatula or glass rod, to promote the disengagement of the muriatic acid gas. After this, the heat may be raised to fully 212° F. for a few minutes. Hot water is to be now poured on in considerable abundance, which dissolves every thing except the silica. By filtration, this earth is separated from the liquid; and being edulcorated with hot water, it is then dried, ignited, and weighed. It constitutes a fine white powder, insoluble in acids, and feeling gritty between the teeth. If it be coloured, a little dilute muriatic acid must be digested on it, to remove the adhering metallic particles, which must be added to the first solution. This must now be reduced by evaporation to the bulk of half a pint. Carbonate of potash being then added, till it indicates alkaline excess, the liquid must be made to boil for a little. A copious precipitation of the earth and oxides is thus produced. The whole is thrown on a filter, and after it is so drained as to assume a semi-solid consistence, it is removed by a platinum blade, and boiled in a capsule for some time, with solution of pure potash. Alumina and glucina are thus dissolved, while the other earths and the metallic oxides remain.

This alkalino-earthy solution, separated from the rest by filtration, is to be treated with an excess of muriatic acid; after which carbonate of ammonia being added also in excess, the alumina is thrown down while the glucina continues dissolved. The first earth separated by filtration, washed, dried, and ignited, gives the quantity of alumina. The nature of this may be further demonstrated, by treating it with dilute sulphuric acid, and sulphate of potash, both in equivalent quantities, when the whole will be converted into alum. The filtered liquid will deposit its glucina, on dissipating the ammonia, by ebullition. It is to be separated by filtration, to be washed, ignited, and weighed.

The matter undissolved by the digestion of the liquid potash, may consist of lime, magnesia, and metallic oxides. Dilute sulphuric acid must be digested on it for some time. The solution is to be evaporated to dryness, and heated to expel the excess of acid. The saline solid matter being now diffused in a moderate quantity of water, the sulphate of magnesia will be dissolved, and along with the metallic sulphates, may be separated from the sulphate of lime by the filter. The latter being washed with a little water, dried, ignited, and weighed, gives, by the scale of equivalents, the quantity of lime in the mineral. The magnesian and metallic solution being diluted with a large quantity of water, is to be treated with bicarbonate of potash, which will precipitate the nickel, iron, and chromium, but retain the magnesia and manganese, by the excess of carbonic acid. Hydrosulphuret of potash will throw down the manganese, from the magnesian solution. The addition of pure potash, aided by gentle ebullition, will then precipitate the magnesia. The oxide of manganese may be freed from the sulphuretted hydrogen, by ustulation.

The mingled metallic oxides must be digested with abundance of nitric acid, to acidify the chromium.

The liquid is next treated with potash, which forms a soluble chromate, while it throws down the iron and nickel. The chromic acid may be separated from the potash by muriatic acid, and digested with heat, washed, dried till it becomes a green oxide, and weighed. The nickel is separated from the iron, by treating their solution in muriatic acid, with water of ammonia. The latter oxide which falls, may be separated by the filter, dried and weighed. By evaporating the liquid, and exposing the dry residue to a moderate heat, the ammoniacal salt will sublime and leave the oxide of nickel behind. The whole separate weights must now be collected in one amount, and if they constitute a sum within two per cent. of the primitive weight, the analysis may be regarded as giving a satisfactory account of the composition of the mineral. But if the deficiency be considerable, then some volatile ingredient, or some alkali or alkaline salt, may be suspected.

A portion of the mineral broken into small fragments, is to be ignited in a porcelain retort, to which a refrigerated receiver is fitted. The water or other volatile and condensable matter, if any be present, will thus be obtained. But if no loss of weight be sustained by ignition, alkali, or a volatile acid, may be looked for. The latter is usually the fluoric. It may be expelled by digestion with sulphuric acid. It is exactly characterised by its property of corroding glass.

Beside this general method, some others may be used in particular cases.

Thus, to discover a small proportion of alumina or magnesia in a solution of a large quantity of lime, pure ammonia may be applied, which will precipitate the alumina or magnesia (if any be), but not the lime. Distilled vinegar applied to the precipitate will discover whether it be alumina or magnesia.

2dly, A minute portion of lime or barytes, in a solution of alumina or magnesia, may be discovered by the sulphuric acid, which precipitates the lime and barytes: the solution should be dilute, else the alumina also would be precipitated. If there be not an excess of acid, the oxalic acid is still a nicer test of lime: 100 grains of gypsum contain about 33 of lime; 100 grains of sulphate of barytes contain 66 of barytes; 100 grains of oxalate of lime contain 43.8 of lime. The insolubility of sulphate of barytes in 500 times its weight of boiling water, sufficiently distinguishes it. From these data the quantities are easily investigated.

3dly, A minute proportion of alumina in a large quantity of magnesia may be discovered. either by precipitating the whole, and treating it with distilled vinegar; or by heating the solution nearly to ebullition, and adding more carbonate of magnesia, until the solution is perfectly neutral, which it never is when alumina is contained in it, as this requires an excess of acid to keep it in solution. By these means the alumina is precipitated in the state of embryon alum, which contains about half its weight of alumina (or, for greater exactness, it may be decomposed by boiling it in volatile alkali). After the precipitation the solution should be largely diluted, as the sulphate of magnesia, which remained in solution while hot, would precipitate when cold, and mix with the embryon alum.

4thly, A minute portion of magnesia in a large quantity of alumina is best separated by precipitating the whole, and treating the precipitate with distilled vinegar.

Lastly, Lime and barytes are separated by precipitating both with the sulphuric acid, and evaporating the solution to a small compass, pouring off the liquor, and treating the dried precipitate with 500 times its weight of boiling water; what remains undissolved is sulphate of barytes.

The inconveniences of employing much heat, are obvious, and Mr. Lowitz informs us, that they may be avoided without the least disadvantage. Over the flame of a spirit lamp, that will hold an ounce and a half, and is placed in a cylindrical tin furnace four inches high and three in diameter, with air-holes, and a cover perforated to hold the crucible, he boils the stone pre-

pared as directed above, stirring it frequently. His crucible, which, as well as the spatula, is of very fine silver, holds two ounces and a half, or three ounces. As soon as the matter is boiled dry, he pours in as much hot water as he used at first; and this he repeats two or three times more, if the refractoriness of the fossil require it. Large tough bubbles arising during the boiling, are in general a sign that the process will be attended with success. Even the sapphire, though the most refractory of all Mr. Lowitz tried, was not more so in this than in the dry way.

Sir H. Davy observes, that the boracic acid is very useful in analyzing stones that contain a fixed alkali; as its attraction for the different earths at the heat of ignition is considerable, and the compounds it forms with them are easily decomposed by the mineral acids dissolved in water. His process is as follows: Let 100 grains of the stone to be examined be reduced to a fine powder, mixed with 200 grains of boracic acid, and fused for about half an hour at a strong red heat in a crucible of platina or silver. Digest the fused mass in an ounce and half of nitric acid diluted with seven or eight times the quantity of water, till the whole is decomposed; and then evaporate the solution till it is reduced to an ounce and half, or two ounces. If the stone contained silex, it will separate in this process, and must be collected on a filter, and edulcorated with distilled water, to separate the saline matter. The fluid, mixed with all the water that has been passed through the filter, being evaporated till reduced to about half a pint, is to be saturated with carbonate of ammonia, and boiled with an excess of this salt, till all that will precipitate has fallen down. The earths and metallic oxides being separated by filtration, mix nitric acid with the clear fluid till it has a strongly sour taste, and then evaporate till the boracic acid remains free. Filter the fluid, evaporate it to dryness, and expose it to heat of 450° F. when the nitrate of ammonia will be decomposed, and the nitrate of potash or soda will remain in the vessel. The earths and metallic oxides, that remained on the filter, may be distinguished by the common processes. The alumina may be separated by solution of potash, the lime by sulphuric acid, the oxide of iron by succinate of ammonia, the manganese by hydrosulphuret of potash, and the magnesia by pure soda.

For analysis of soils. See SOILS.

For analysis of vegetables. See VEGETABLE KINGDOM.

ANATASE, a very rare mineral, found only in Dauphiny and Norway.

ANDALUSITE, a mineral first found in Andalusia. It consists of 52 alumina, 32 silica, 8 potash, 2 oxide of iron, and 6 loss in 100 parts.

ANDREOLITE. See CROSS-STONE.

ANHYDRITE. Anhydrous gypsum, of which there are six varieties. The compact, the granular, the fibrous, the radiated, the sparry, and the siliciferous or Vulpinite. The last takes its name from Vulpino in Italy. It takes a fine polish, and is esteemed by statuaries. It contains 92 sulphate of lime, and 8 silica, in the 100. Its colour is greyish white, veined with bluish grey. Specific gravity 2.88.

ANIL, or NIL, an American plant, from the leaves of which indigo is prepared.

ANIMAL KINGDOM. The various bodies around us, which form the objects of chemical research, have all undergone a number of combinations and decompositions before we take them in hand for examination. These are all consequences of the same attractions or specific properties that we avail ourselves of, and are modified likewise by virtue of the situations and temperatures of the bodies presented to each other. In the great mass of unorganized matter, the combinations appear to be much more simple than such as take place in the vessels of organized beings, namely, plants and animals: in the former of which there is not any peculiar structure of tubes conveying various fluids; and

in the latter there is not only an elaborate system of vessels, but likewise, for the most part, an augmentation of temperature.—From such causes as these it is, that some of the substances afforded by animal bodies are never found either in vegetables or minerals; and so likewise in vegetables are found certain products never unequivocally met with among minerals. Hence, among the systematical arrangements used by chemists, the most general is that which divides bodies into three kingdoms, the animal, the vegetable, and the mineral.

Animal, as well as vegetable bodies, may be considered as peculiar apparatus for carrying on a determinate series of chemical operations. Vegetables seem capable of operating with fluids only, and at the temperature of the atmosphere. But most animals have a provision for mechanically dividing solids by mastication, which answers the same purpose as grinding, pounding, or levigation, does in our experiments; that is to say, it enlarges the quantity of surface to be acted upon by solvents. The process carried on in the stomach appears to be of the same kind as that which we distinguish by the name of digestion; and the bowels, whatever other uses they may serve, evidently form an apparatus for filtering or conveying off the fluids; while the more solid parts of the aliments, which are probably of such a nature as not to be rendered fluid, but by an alteration which would perhaps destroy the texture of the machine itself, are rejected as useless. When this filtered fluid passes into the circulatory vessels, through which it is driven with considerable velocity by the mechanical action of the heart, it is subjected, not only to all those changes which the chemical action of its parts is capable of producing, but is likewise exposed to the air of the atmosphere in the lungs, into which that elastic fluid is admitted by the act of respiration. Here it undergoes a change of the same nature as happens to other combustible bodies when they combine with its vital part, or oxygen. This vital part becomes condensed, and combines with the blood, at the same time that it gives out a large quantity of heat, in consequence of its own capacity for heat being diminished. A small portion of azote likewise is absorbed, and carbonic acid is given out. Some curious experiments of Spallanzani show that the lungs are not the sole organs by which these changes are effected. Worms, insects, shells of land and sea animals, egg shells, fishes, dead animals, and parts of animals, even after they have become putrid, are capable of absorbing oxygen from the air, and giving out carbonic acid. They deprive atmospheric air of its oxygen as completely as phosphorus. Shells, however, lose this property when their organization is destroyed by age. Amphibia, deprived of their lungs, lived much longer in the open air, than others in air destitute of oxygen. It is remarkable, that a larva, weighing a few grains, would consume almost as much oxygen in a given time as one of the amphibia a thousand times its bulk. Fishes, alive and dead, animals, and parts of animals, confined under water in jars, absorbed the oxygen of the atmospheric air over the water. Muscles, tendons, bones, brain, fat, and blood, all absorbed oxygen in different proportions, but the blood did not absorb most; and bile appeared not to absorb any.

It would lead us too far from our purpose if we were to attempt an explanation of the little we know respecting the manner in which the secretions or combinations that produce the various animal and vegetable substances are effected, or the uses of those substances in the economy of plants and animals. Most of them are very different from any of the products of the mineral kingdom. We shall therefore only add, that these organized beings are so contrived, that their existence continues, and all their functions are performed, as long as the vessels are supplied with food or materials to occupy the place of such as are carried off by evaporation from the surface, or otherwise, and as long as no great change is

made, either by violence or disease, in those vessels, or the fluids they contain. But as soon as the entire process is interrupted in any very considerable degree, the chemical arrangements become altered, the temperature in land animals is changed, the minute vessels are acted upon and destroyed, life ceases, and the admirable structure, being no longer sufficiently perfect, loses its figure, and returns, by new combinations and decompositions, to the general mass of unorganized matter, with a rapidity which is usually greater the more elaborate its construction.

The parts of vegetable or animal substances may be obtained, for chemical examination, either by simple pressure, which empties the vessels of their contents; by digestion in water, or in other fluids, which dissolve certain parts, and often change their nature; by destructive distillation, in which the application of a strong heat alters the combination of the parts, and causes the new products to pass over into the receiver in the order of their volatility; by spontaneous decomposition or fermentation, wherein the component parts take a new arrangement, and form compounds which did not for the most part exist in the organized substance; or, lastly, the judicious chemist will avail himself of all these several methods singly, or in combination. He will, according to circumstances, separate the parts of an animal or vegetable substance by pressure, assisted by heat; or by digestion or boiling in various fluids added in the retort which contains the substance under examination. He will attend particularly to the products which pass over, whether they be permanently elastic, or subject to condensation in the temperatures we are able to produce. In some cases, he will suffer the spontaneous decomposition to precede the application of chemical methods; and in others he will attentively mark the changes which the products of his operations undergo in the course of time, whether in closed vessels, or exposed to the open air. Thus it is that, in surveying the ample field of nature, the philosophical chemist possesses numerous means of making discoveries, if applied with judgment and sagacity; though the progress of discovery, so far from bringing us nearer the end of our pursuit, appears continually to open new scenes, and, by enlarging our powers of investigation, never fails to point out additional objects of inquiry.

Animal and vegetable substances approach each other by insensible gradations; so that there is no simple product of the one which may not be found in greater or less quantity in the other. The most general distinctive character of animal substances is that of affording volatile alkali by destructive distillation. Some plants, however, afford it likewise. Neither contain it ready formed; but it appears to be produced by the combination of hydrogen and azote, during the changes produced either by fire, or by the putrefactive process.

Our knowledge of the products of the animal kingdom, by the help of chemical analysis, is not yet sufficiently matured to enable us to arrange them according to the nature of their component parts, which appear to consist chiefly of hydrogen, oxygen, carbon, and azote; and with these sulphur, phosphorus, lime, magnesia, and soda, are frequently combined in variable proportions.

When animal substances are left exposed to the air, or immersed in water or other fluids, they suffer a spontaneous change, which is more or less rapid according to circumstances. The spontaneous change of organized bodies is distinguished by the name of fermentation. In vegetable bodies there are distinct stages or periods of this process, which have been divided into the vinous, acetous, and putrefactive fermentations. Animal substances are susceptible only of the two latter, during which, as in all other spontaneous changes, the combinations of chemical principles become in general more and more simple. There is no doubt but much instruction might be obtained from accurate observations of the

putrefactive processes in all their several varieties and situations; but the loathsomeness and danger attending on such inquiries has hitherto greatly retarded our progress in this department of chemical science.

For further information respecting the chemical products of animal organization, see the articles ALBUMEN, BILE, BLOOD, BONE, BRAIN, FIBRIN, GELATIN, MUCUS, PICROMEL, UREA.

ANIME, improperly called gum anime, is a resinous substance imported from New Spain and the Brazils. There are two kinds, distinguished by the names of oriental and occidental. The former is dry, and of an uncertain colour, some specimens being greenish, some reddish, and some of the brown colour of myrrh. The latter is in yellowish, white, transparent, somewhat unctuous tears, and partly in larger masses, brittle, of a light pleasant taste, easily melted in the fire, and burning with an agreeable smell. Like resins, it is totally soluble in alcohol, and also in oil. Water takes up about 1-16th of the weight of this resin by decoction. The spirit, drawn off by distillation, has a considerable degree of the taste and flavour of the anime; the distilled water discovers on its surface some small portion of essential oil.

This resin is used by perfumers, and also in certain plasters, wherein it has been supposed to be of service in nervous affections of the head and other parts; but there are no reasons to think that, for medical purposes, it differs from common resins.

ANNEAL. We know too little of the arrangement of particles to determine, what it is that constitutes or produces brittleness in any substance. In a considerable number of instances of bodies which are capable of undergoing ignition, it is found that sudden cooling renders them hard and brittle. This is a real inconvenience in glass, and also in steel, when this metallic substance is required to be soft and flexible. The inconveniences are avoided by cooling them very gradually, and this process is called annealing. Glass vessels, or other articles, are carried into an oven or apartment near the great furnace, called the leer, where they are permitted to cool, in a greater or less time, according to their thickness and bulk. The annealing of steel, or other metallic bodies, consists simply in heating them, and suffering them to cool again either upon the hearth of the furnace, or in any other situation where the heat is moderate, or at least the temperature is not very cold.

ANNOTTO. The pellicles of the seeds of the *bixa orellana*, a liliaceous shrub, from 15 to 20 feet high in good ground, afford the red masses brought into Europe under the name of Annotto, Orlean, and Roucou.

ANTHOPHYLLITE. A mineral found at Konigsberg, in Norway, of specific gravity 3.2, and consisting of 56 silica, 13.3 alumina, 14 magnesia, 3.33 lime, 6 oxide of iron, 3 oxide of manganese, 1.43 water, and 2.94 loss. in 100 parts.

ANTHRACITE. Blind coal, Kilkenny coal, or Glance coal. This mineral is thus described by Brogniart.

Anthracite so much resembles coal at first sight, that for a long time it was taken for a variety of that combustible mineral. Nevertheless, artisans who used it had remarked that it burnt with great difficulty, and did not produce either that white flame, or black smoke, or that bituminous colour, which arises from coal; therefore it was called incombustible pit coal.

Anthracite is of a black less opaque than coal; its colour approaches nearer, by its brightness, to the metallic black, it is also more friable; it is rough to the touch, and easily stains the fingers; it leaves a black mark on paper which, if examined with attention, seems of a dull black. These characters serve to distinguish it from graphite, which leaves a bright mark and is unctuous to the feel.

The texture of anthracite, sometimes schistose, sometimes compact, at others granular, is too various to serve as a characteristic. Its specific gravity, which is 1.8, is infe-

rior to that of graphite, in the proportion of 9 to 14, and exceeds that of coal as 9 to 7.

This mineral is decidedly opaque; it easily allows the electric spark to pass, is hard to burn, and in its combustion never produces but one substance, which is carbonic acid.

The matter essential to its composition is mixed carbon, or perhaps combined sometimes with silex and iron, sometimes with argil and silex, in very different proportions, according to analyzed specimens.

ANTIMONY. The word antimony is always used in commerce to denote a metallic ore, consisting of sulphur combined with the metal which is properly called antimony. Sometimes this sulphuret is termed crude antimony, to distinguish it from the pure metal, or regulus, as it was formerly called. According to Prof. Proust, the sulphuret contains 26 per cent. of sulphur. He heated 100 parts of antimony with an equal weight of sulphur in a glass retort, till the whole was well fused and the excess of sulphur expelled, and the sulphuret remaining was 135. The result was the same after repeated trials: 100 parts of antimony, with 300 of red sulphuret of mercury, afforded 135 to 136 of sulphur. These artificial sulphurets lost nothing by being kept in fusion an hour; and heated with an equal weight of sulphur, they could not be made to take up more. Some of the native sulphurets of the shops, however, appear to have a small portion more of sulphur united with them, as they will take up an addition of 7 or 8 per cent. of antimony.

Antimony is of a dusky white colour, very brittle, and of a plated or scaly texture. Its specific gravity, according to Brisson, is 6.7021, but Bergman makes it 6.86. Soon after ignition it melts, and by a continuance of the heat it becomes oxidized, and rises in white fumes, which may afterward be volatilized a second time, or fused into a hyacinthine glass, according to the management of the heat: the first were formerly called argentine flowers of regulus of antimony. In closed vessels the antimony rises totally without decomposition.—This metallic substance is not subject to rust by exposure to air, though its surface becomes tarnished by that means. Its oxides are a little soluble in water; and in this respect they resemble the oxide of arsenic, by an approach toward the acid state.

There are three, and probably four, oxides of antimony. The protoxide consists of 100 of the metal and 4.65 oxygen. The deutoxide contains a double quantity of oxygen. The tritoxide has a triple quantity; and the peroxide a quadruple quantity.

Chlorine gas and antimony combine and form a soft fatty substance, called butter of antimony. It was formerly prepared by distilling two parts of corrosive sublimate and one of antimony.

Tartar emetic is a salt which consists, according to Thenard, of 35.4 tartaric acid, 39.6 oxide of antimony, 16.7 potass, and 8.2 water. It is much used in medicine. Alkalis decompose it, as do also strong decoctions of cinchona, and several bitter and astringent plants, which is matter of much importance to a physician.

James's powder, a powerful medicine in fevers, is said, by Dr. Pearson, to consist of 57 oxide of antimony, and 43 phosphate of lime.

ANTS, on being analyzed, yield a peculiar acid, which is denominated the formic acid, which see.

APATITE. Phosphate of lime, consisting, according to Klaproth, of 53.75 lime and 46.25 phosphoric acid. It occurs in primitive rocks, is found in the tin veins of the granite of St. Michael's mount Cornwall. It phosphoresces on coals, and becomes electric by heat and friction.

APHRITE. Earth Foam. This is a carbonate of lime, consisting, according to Bucholz, of 51.5 lime, 39 acid, 1 water, 5.7 silica, and 3.3 oxide of iron. It occurs usually in a friable state, and is sometimes solid.

APLOME. A mineral of a deep

orange brown, opaque and harder than quartz, consisting, according to Laugier, of 40 silica, 20 alumina, 14.5 lime, 14 oxide of iron, 2 oxide of manganese, 2 silica and iron. It is frequently considered to be a variety of garnet, but there is a slight difference in the crystals, and it fuses into a black glass, whilst garnet fuses into a black enamel. It is found on the river Lena in Siberia, and also in New Holland.

APOPHYLLITE. Ichthyophthalmite. Fish-eye stone. Consists of 51 silica, 28 lime, 4 potass, 17 water.

APPARATUS. The various vessels, crucibles, furnaces, machines, and instruments, for conducting researches and experiments.

APPLES. In addition to the usual substance found in fruit, apples contain a peculiar acid called the malic acid, which is the same as that found in the mountain ash.

APYROUS. Bodies which sustain the action of a strong heat for a considerable time, without change of figure or other properties, have been called apyrous; but the word is seldom used in the art of chemistry. It is synonymous with *refractory*.

AQUAFORTIS. This name is given to a weak and impure nitric acid, commonly used in the arts. It is distinguished by the terms *double* and *single*, the single being only half the strength of the other. The artists who use these acids call the more concentrated acid, which is much stronger even than the double aquafortis, *spirit of nitre*.

AQUA MARINE, the same as Beryl, which see.

AQUA REGIA, OR REGIS. A mixture of the nitric and muriatic acid, now usually called nitro-muriatic acid, and has been called by this name, signifying royal water, from its having the property of dissolving gold; which neither of them will effect separately; and which no single acid in common use could do.

AQUA VITÆ. Ardent spirit of the first distillation has been distinguished in commerce by this name. The distillers of malt and molasses spirits call it low wines.

AQUILA ALBA. One of the names given to the combination of muriatic acid and mercury in that state, which is more commonly known by the denomination of *mercurius dulcis*, *calomel*, or *mild muriate of mercury*.

ARABIC (Gum), is obtained naturally from the acacia in Egypt, Arabia, and elsewhere. This is reckoned the purest of gums, and does not greatly differ from gum Senegal, vulgarly called gum seneca, which is supposed to be the strongest, and is on this account, as well as its greater plenty and cheapness, mostly used by calico-printers and other manufacturers. The gums of the plum and the cherry-tree have nearly the same qualities as gum arabic. All these substances facilitate the mixture of oils with water.

ARABLE LANDS. It is a problem in chemistry, and by no means one of the least importance to society, to determine what are the requisites which distinguish fruitful lands from such as are less productive. See SOILS.

ARBOR DIANÆ, is produced from a solution of silver, into which mercury is poured. The silver gradually precipitates in a very curious and beautiful symmetrical arrangement, which has been called the tree of Diana. Luna, or Diana, was the symbolical name given by alchemists to silver, in conformity with their system of wrapping up their art in secret mystery.

ARCHIL, ARCHILLA, ROCELLA, ORSEILLE. A whitish lichen, growing upon rocks in the Canary and Cape Verd islands, which yields a rich purple tincture, fugitive indeed, but extremely beautiful. This weed is imported to us as it is gathered: those who prepare it for the use of the dyer, grind it betwixt stones, so as thoroughly to bruise, but not to reduce it into powder, and then moisten it occasionally with a strong spirit of urine, or urine itself mixed with quicklime: in a few days it acquires a purplish red, and at length a blue colour; in the first state it is called archil, in the latter lacmus, or litmus.

The dyers rarely employ this

drug by itself, on account of its dearness, and the perishableness of its beauty. The chief use they make of it is for giving a bloom to other colours, as pinks, &c. This is effected by passing the dyed cloth or silk through hot water slightly impregnated with the archil. The bloom thus communicated soon decays upon exposure to the air. Mr. Hellot informs us, that by the addition of a little solution of tin, this drug gives a durable dye; that its colour is at the same time changed toward a scarlet; and that it is the more permanent, in proportion as it recedes the more from its natural colour.

Prepared archil very readily gives out its colour to water, to volatile spirits, and to alcohol: it is the substance principally made use of for colouring the spirits of thermometers. As exposure to the air destroys its colour upon cloth, the exclusion of the air produces a like effect in those hermetically sealed tubes, the spirits of large thermometers becoming in a few years colourless. The Abbe Nollet observes, (in the French Memoirs for the year 1742), that the colourless spirit, upon breaking the tube, soon resumes its colour, and this for a number of times successively; that a watery tincture of archil, included in the tubes of thermometers, lost its colour in three days; and that in an open deep vessel, it became colourless at the bottom, while the upper part retained its colour.

A solution of archil in water, applied on cold marble, stains it of a beautiful violet or purplish blue colour, far more durable than the colour which it communicates to other bodies. M. du Fay says, he has seen pieces of marble stained with it, which in two years had suffered no sensible change. It sinks deep into the marble, sometimes above an inch, and at the same time spreads upon the surface, unless the edges be bounded by wax or some similar substance. It seems to make the marble somewhat more brittle.

There is a considerable consumption of an article of this kind manufactured in Glasgow by Mr. Mackintosh. It is much esteemed, and sold by the name of cudbear. We have seen beautiful specimens of silk thus dyed, the colours of which were said to be very permanent, of various shades, from pink and crimson to a bright mazarine blue.

Litmus is likewise used in chemistry as a test, either staining paper with it, or by infusing it in water, when it is very commonly, but with great impropriety, called *tincture of turnsole*. The persons by whom this article was prepared, formerly gave it the name of turnsole, pretending that it was extracted from the turnsole, heliotropium tricoccum, in order to keep its true source a secret. The tincture should not be too strong, otherwise it will have a violet tinge, which, however, may be removed by dilution. The light of the sun turns it red even in close vessels. It may be made with spirit instead of water. This tincture, or paper stained with it, is presently turned red by acids: and if it be first reddened by a small quantity of vinegar, or some weak acid, its blue colour will be restored by an alkali.

ARCTIZITE. A mineral, the same as wernerite or foliated scapolite.

ARDENT SPIRIT is another name for alcohol.

AREOMETER, the same as hydrometer, which see.

ARGAL, the name given in commerce to the crude tartar, formed in the inside of wine casks. See Tartar.

ARGENTATE OF AMMONIA, fulminating silver.

ARGILLACEOUS EARTH, the same as alumina, which see.

ARGILLITE. See Clay slate.

AROMATICS. Plants which possess a fragrant smell united with pungency, and at the same time are warm to the taste, are called aromatics. Their peculiar flavour appears to reside in their essential oil, and rises in distillation either with water or spirit.

ARRACK. A spirituous liquor imported from the East Indies. It is chiefly manufactured at Batavia, and at Goa upon the Malabar coast.

ARRAGONITE. A mineral first found in Arragon, in Spain. It consists of carbonate of lime, with occasionally a little carbonate of strontites. It occurs massive, in fibres of a silky lustre, and in the form of fibrous branches, diverging from a centre flos ferri. It is frequently crystallized, in what appear, at first sight, regular six-sided prisms. It is translucent, refracts doubly. Specific gravity 2.90.

ARSENIC, in the metallic state, is of a bluish white colour, subject to tarnish, and grow first yellowish, then black, by exposure to air. It is brittle, and when broken exhibits a laminated texture. Its specific gravity is 5.763. In close vessels it sublimes entire at 356° F. but burns with a small flame if respirable air be present.

The arsenic met with in commerce has the form of a white oxide. It is brought chiefly from the cobalt works in Saxony, where zaffre is made. Cobalt ores contain much arsenic, which is driven off by long torrefaction. The ore is thrown into a furnace resembling a baker's oven, with a flue, or horizontal chimney, nearly two hundred yards long, into which the fumes pass, and are condensed into a greyish or blackish powder. This is refined by a second sublimation in close vessels, with a little potash, to detain the impurities. As the heat is considerable, it melts the sublimed flowers into those crystalline masses which are met with in commerce.

The metal may be obtained from this, either by quickly fusing it together with twice its weight of soft soap and an equal quantity of alkali, and pouring it out, when fused, into a hot iron cone; or by mixing it in powder with oil, and exposing it in a matrass to a sand heat. This process is too offensive to be performed, except in the open air, or where a current of air carries off the fumes. The decomposed oil first rises; and the arsenic is afterwards sublimed, in the form of a flaky metallic substance. It may likewise be obtained by mixing two parts of the arsenious acid with one of black flux; putting the mixture into a crucible, with another inverted over it, and luted to it with clay and sand; and applying a red heat to the lower crucible. The metal will be reduced, and line the inside of the upper crucible.

It is among the most combustible of the metals, burns with a blue flame, and garlic smell, and sublimes in the state of arsenious acid.

Concentrated sulphuric acid does not attack arsenic when cold; but if it be boiled upon this metal, sulphurous acid gas is emitted, a small quantity of sulphur sublimes, and the arsenic is reduced to an oxide.

Nitrous acid readily attacks arsenic, and converts it into arsenious acid, or, if much be employed into arsenic acid.

Boiling muriatic acid dissolves arsenic, but affects it very little when cold. This solution affords precipitates upon the addition of alkalis. The addition of a little nitric acid expedites the solution; and this solution, first heated and condensed in a close vessel, is wholly sublimed into a thick liquid, formerly termed *butter of arsenic*. Thrown in powder into chlorine gas, it burns with a bright white flame, and is converted into a chloride.

None of the earths or alkalis act upon it, unless it be boiled a long while in fine powder, in a large proportion of alkaline solution.

Nitrates detonate with arsenic, convert it into arsenic acid, and this, combining with the base of the nitrate, forms an arseniate, that remains at the bottom of the vessel.

Muriates have no action upon it; but if three parts of chlorate of potash be mixed with one part of arsenic in fine powder, which must be done with great precaution, and a very light hand, a very small quantity of this mixture, placed on an anvil, and struck with a hammer, will explode with flame and a considerable report; if touched with fire, it will burn with considerable rapidity; and if thrown into concentrated sulphuric acid, at the instant of contact a flame rises into the air like a flash of lightning, which is so bright as to dazzle the eye.

Arsenic readily combines with

sulphur by fusion and sublimation, and forms a yellow compound called *orpiment*, or a red called *realgar*. The nature of these, and their difference, are not accurately known; but Fourcroy considers the first as a combination of sulphur with the oxide, and the second as a combination of sulphur with the metal itself, as he found the red sulphuret converted into the yellow by the action of acids.

Arsenic is soluble in fat oils in a boiling heat; the solution is black, and has the consistence of an ointment when cold. Most metals unite with arsenic; which exists in the metallic state in such alloys as possess the metallic brilliancy.

Arsenic is used in a variety of arts. It enters into metallic combinations, wherein a white colour is required. Glass manufacturers use it; but its effect in the composition of glass does not seem to be clearly explained. Orpiment and realgar are used as pigments. See ARSENIC and ARSENIOUS ACIDS.

Arsenic unites with iodine, forming a substance of a dark purple colour, possessing the properties of an acid. It also combines with hydrogen, forming a most noxious gas.

ARSENIC ACID. The earliest chemists were embarrassed in the determination of the nature of the white sublimate, which is obtained during the roasting of cobalt and other metallic ores, known in commerce by the name of arsenic: its solubility in water, its power of combining with metals in their simple state, together with other apparently heterogeneous properties, rendered it difficult to determine whether it ought to be classed with metals or salts. Subsequent discoveries have shown the relation it bears to both. When treated with combustible matter, in close vessels, it sublimes in the metallic form; combustion, or any analogous process, converts it into an oxide; and when the combustion is carried still further, the arsenical basis becomes itself converted into an acid.

We are indebted to the illustrious Scheele for the discovery of this acid, though Macquer had before noticed its combinations. It may be obtained by various methods. If six parts of nitric acid be poured on one of the concrete arsenious acid, or white arsenic of the shops, in the pneumato-chemical apparatus, and heat be applied, nitrous gas will be evolved, and a white concrete substance, differing in its properties from the arsenious acid, will remain in the retort. This is the arsenic acid. It may equally be procured by means of aqueous chlorine, or by heating concentrated nitric acid with twice its weight of the solution of the arsenious acid in muriatic acid. The concrete acid should be exposed to a dull red heat for a few minutes. In either case an acid is obtained, that does not crystallize, but attracts the moisture of the air, has a sharp caustic taste, reddens blue vegetable colours, is fixed in the fire, and of the specific gravity of 3.391.

If the arsenic acid be exposed to a red heat in a glass retort, it melts and becomes transparent, but assumes a milky hue on cooling. If the heat be increased, so that the retort begins to melt, the acid boils, and sublimes into the neck of the retort. If a covered crucible be used instead of the glass retort, and a violent heat applied, the acid boils strongly, and in a quarter of an hour begins to emit fumes. These, on being received in a glass bell, are found to be arsenious acid; and a small quantity of a transparent glass, difficult to fuse, will be found lining the sides of the crucible. This is arseniate of alumina.

Combustible substances decompose this acid. If two parts of arsenic acid be mixed with about one of charcoal, the mixture introduced into a glass retort, coated, and a matrass adapted to it; and the retort then gradually heated in a reverberatory furnace, till the bottom is red; the mass will be inflamed violently, and the acid reduced, and rise to the neck of the retort in the metallic state mixed with a little oxide and charcoal powder. A few drops of water, devoid of acidity, will be found in the receiver.

With sulphur the phenomena are

different. If a mixture of six parts of arsenic acid, and one of powdered sulphur, be digested together, no change will take place; but on evaporating to dryness, and distilling in a glass retort, fitted with a receiver, a violent combination will ensue, as soon as the mixture is sufficiently heated to melt the sulphur. The whole mass rises almost at once, forming a red sublimate, and sulphurous acid passes over into the receiver.

If pure arsenic acid be diluted with a small quantity of water, and hydrogen gas, as it is evolved by the action of sulphuric acid on iron, be received into this transparent solution, the liquor grows turbid, and a blackish precipitate is formed, which, being well washed with distilled water, exhibits all the phenomena of arsenic. Sometimes, too, a blackish grey oxide of arsenic is found in this process.

If sulphuretted hydrogen gas be employed instead of simple hydrogen gas, water and a sulphuret of arsenic are obtained.

With phosphorus, phosphoric acid is obtained, and a phosphuret of arsenic, which sublimes.

The arsenic acid is much more soluble than the arsenious. According to Lagrange, two parts of water are sufficient for this purpose. It cannot be crystallized by any means; but, on evaporation, assumes a thick honey-like consistence.

No acid has any action upon it; if some of them dissolve it by means of the water that renders them fluid, they do not produce any alteration in it. The boracic and phosphoric are vitrifiable with it by means of heat, but without any material alteration in their natures. If phosphorous acid be heated upon it for some time, it saturates itself with oxygen, and becomes phosphoric acid.

The arsenic acid combines with the earthy and alkaline bases, and forms salts very different from those furnished by the arsenious acid.

All these arseniates are decomposable by charcoal, which separates arsenic from them by means of heat.

The arseniate of barytes is insoluble, uncrystallizable, soluble in an excess of its acid, and decomposable by sulphuric acid, which precipitates a sulphate of barytes.

Of the arseniate of strontian nothing is known, but no doubt it resembles that of barytes.

With lime-water this acid forms a precipitate of arseniate of lime, soluble in an excess of its base, or in an excess of its acid, though insoluble alone. The acidulous arseniate of lime affords on evaporation little crystals, decomposable by sulphuric acid. The same salt may be formed by adding carbonate of lime to the solution of arsenic acid. This acid does not decompose the nitrate or muriate of lime; but the saturated alkaline arseniates decompose them by double affinity, precipitating the insoluble calcareous arseniate.

If arsenic acid be saturated with magnesia, a thick substance is formed near the point of saturation. This arseniate of magnesia is soluble in an excess of acid; and on being evaporated takes the form of a jelly, without crystallizing. Neither the sulphate, nitrate, nor muriate of magnesia is decomposed by arsenic acid, though they are by the saturated alkaline arseniates.

Arsenic acid saturated with potash does not easily crystallize. This arseniate, being evaporated to dryness, attracts the humidity of the air, and turns the sirup of violets green, without altering the solution of litmus. It fuses into a white glass, and with a strong fire is converted into an acidule, part of the alkali being abstracted by the silex and alumina of the crucible. If exposed to a red heat with charcoal in close vessels it swells up very much, and arsenic is sublimed. It is decomposed by sulphuric acid; but in the humid way the decomposition is not obvious, as the arsenic acid remains in solution. On evaporation, however, this acid and sulphate of potash are obtained.

If arsenic acid be added to the preceding salt, till it ceases to have any effect on the syrup of violets, it will redden the solution of litmus; and in this state it affords very regular and very transparent crys-

tals, of the figure of quadrangular prisms, terminated by two tetraedral pyramids, the angles of which answer to those of the prisms. These crystals are the arsenical neutral salt of Macquer. As this salt differs from the preceding arseniate by its crystallizability, its reddening solution of litmus, its not decomposing the calcareous and magnesian salts like it, and its capability of absorbing an additional portion of potash, so as to become neutral, it ought to be distinguished from it by the term of acidulous arseniate of potash.

With soda in sufficient quantity to saturate it, arsenic acid forms a salt crystallizable like the acidulous arseniate of potash. Pelletier says, that the crystals are hexaedral prisms terminated by planes perpendicular to their axis. This neutral arseniate of soda, however, while it differs completely from that of potash in this respect, and in becoming deliquescent instead of crystallizable on the addition of a surplus portion of arsenic acid, resembles the arseniate of potash in its decomposition by charcoal, by acids, and by the earths.

Combined with ammonia, arsenic acid forms a salt affording rhomboidal crystals analogous to those of the nitrate of soda. The arseniate of ammonia, which is produced likewise in the decomposition of nitrate of ammonia by arsenious acid, is decomposable in two ways by the action of heat. If it be gently heated, the ammonia is evolved, and the arsenic acid is left pure. If it be exposed to a violent and rapid heat, part of the ammonia and part of the acid reciprocally decompose each other; water is formed; azotic gas is given out; and the arsenic sublimes in a shining metallic form. Magnesia partly decomposes the arseniate of ammonia, and forms a triple salt with a portion of it.

Arsenic acid saturated with alumina forms a thick solution, which, being evaporated to dryness, yields a salt insoluble in water, and decomposable by the sulphuric, nitric and muriatic acids, as well as by all the other earthy and alkaline bases. The arsenic acid readily dissolves the alumina of the crucibles in which it is reduced to a state of fusion; and thus it attacks silex also, on which it has no effect in the humid way.

We know nothing of the combination of this acid with zircone.

By the assistance of a strong fire, as Fourcroy asserts, arsenic acid decomposes the alkaline and earthy sulphates, even that of barytes; the sulphuric acid flying off in vapour, and the arseniate remaining in the retort. It acts in the same manner on the nitrate, from which it expels the pure acid. It likewise decomposes the muriates at a high temperature, the muriatic acid being evolved in the form of gas, and the arsenic acid combining with their bases, which it saturates; while the arsenious acid is too volatile to have this effect. It acts in the same manner on the fluates, and still more easily on the carbonates, with which, by the assistance of heat, it excites a brisk effervescence. Lagrange, however, denies that it acts on any of the neutral salts, except the sulphate of potash and soda, the nitrate of potash, and the muriates of soda and ammonia, and this by means of heat. It does not act on the phosphates, but precipitates the boracic acid from solutions of borates when heated.

Arsenic acid does not act on gold or platina; neither does it on mercury or silver without the aid of a strong heat; but it oxidizes copper, iron, lead, tin, zinc, bismuth, antimony, cobalt, nickel, manganese, and arsenic.

This acid is not used in the arts, at least directly, though indirectly it forms a part of some compositions used in dying. It is likewise one of the mineralizing acids combined by nature with some of the metallic oxides.

ARSENIOUS ACID. Fourcroy was the first who distinguished by this name the white arsenic of the shops, which Scheele had proved to be a compound of the metal arsenic with oxygen, and which the authors of the new chemical nomenclature had consequently termed oxide of arsenic. As, however, it manifestly exhibits the properties of an acid, though in a slight degree, it has a

fair claim to the title; for many oxides and acids are similar in this, that both consist of a base united with oxygen, and the only difference between them is, that the compound in which the acid properties are manifest, is termed an acid, and that in which they are not, is called an oxide.

This acid, which is one of the most virulent poisons known, frequently occurs in a native state, if not very abundantly; and it is obtained in roasting several ores, particularly those of cobalt. In the chimneys of the furnaces where this operation is conducted, it generally condenses in thick semi-transparent masses; though sometimes it assumes the form of a powder, or of little needles, in which state it was formerly called flowers of arsenic.

The arsenious acid reddens the most sensible blue vegetable colours, though it turns the sirup of violets green. On exposure to the air it becomes opaque, and covered with a slight efflorescence. Thrown on incandescent coals, it evaporates in white fumes, with a strong smell of garlic. In close vessels it is volatilized; and, if the heat be strong, vitrified. The result of this vitrification is a transparent glass, capable of crystallizing in tetraedra, the angles of which are truncated. It is easily altered by hydrogen and carbon, which deprive it of its oxygen at a red heat, and reduce the metal, the one forming water, the other carbonic acid, with the oxygen taken from it: as it is by phosphorus, and by sulphur, which are in part converted into acids by its oxygen, and in part form an arsenical phosphuret or sulphuret with the arsenic reduced to the metallic state. Hence Margraaf and Pelletier, who particularly examined the phosphurets of metals, have asserted they might be formed with arsenious acid. Its specific gravity is 3.7.

It is soluble in thirteen times its weight of boiling water, but requires eighty times its weight of cold. The solution crystallizes, and the acid assumes the form of regular tetraedrons according to Fourcroy; but, according to Lagrange, of octaedrons, and these frequently varying in figure by different laws of decrement. It crystallizes much better by slow evaporation than by simple cooling.

There are even some metals, which act upon the solution, and have a tendency to decompose the acid, so as to form a blackish precipitate, in which the arsenic is very slightly oxidized.

The action of the other acids upon the arsenious is very different from that which they exert on the metal arsenic. By boiling, sulphuric acid dissolves a small portion of it, which is precipitated as the solution cools. The nitric acid does not dissolve it, but by the help of heat converts it into arsenic acid. Neither the phosphoric nor the carbonic acid acts upon it; yet it enters into a vitreous combination with the phosphoric and boracic acids. The muriatic acid dissolves it by means of heat, and forms with it a volatile compound, which water precipitates; and aqueous chlorine acidifies it completely, so as to convert it into arsenic acid.

The arsenious acid combines with the earthy and alkaline bases. The earthy arseniates possess little solubility, and hence the solutions of barytes, strontian, and lime, form precipitates with that of arsenious acid.

This acid enters into another kind of combination with the earths, that are formed by vitrification. Though a part of this volatile acid sublimes before the glass enters into fusion, part remains fixed in the vitrified substance, to which it imparts transparency, a homogeneous density, and considerable gravity. The arsenical glasses appear to contain a kind of triple salt, since the salt and alkalis enter into an intimate combination at the instant of fusion, and remain afterward perfectly mixed. All of them have the inconvenience of quickly growing dull by exposure to the air.

With the fixed alkalis the arsenious acid forms thick arseniates, which do not crystallize; which are decomposable by fire, the arsenious acid being volatilized by the heat; and from which all the other acids precipitate this in powder. These saline compounds were formerly

termed livers, because they were supposed to be analogous to the combinations of sulphur with the alkalis.

With ammonia it forms a salt capable of crystallization. If this be heated a little, the ammonia is decomposed, the nitrogen is evolved, while the hydrogen, uniting with part of the oxygen of the acid, forms water.

Neither the earthy nor alkaline arseniates have yet been much examined; what is known of them being only sufficient to distinguish them from the arseniates.

The nitrates act on the arsenious acid in a very remarkable manner. On treating the nitrates and arsenious acid together, the nitrous acid, or nitrous vapour, is extricated in a state very difficult to be confined, as Kunckel long ago observed; part of its oxygen is absorbed by the arsenious acid; it is thus converted into arsenic acid, and an arseniate is left in the retort. The same phenomena take place on diluting nitrates with arsenious acid; for it is still sufficiently combustible to produce a detonation, in which no sparks are seen, it is true, but with commotion and effervescence; and a true arseniate remains at the bottom of the crucible. It was in this way chemists formerly prepared their fixed arsenic, which was the acidulous arseniate of potash. The nitrate of ammonia exhibits different phenomena in its decomposition by arsenious acid, and requires considerable precaution. Pelletier mixed equal quantities, and introduced the mixture into a large retort of coated glass, placed in a reverberatory furnace with a glass receiver. He began with a very slow fire; for the decomposition is so rapid, and the nitrous vapours issue with such force, that a portion of the arsenious acid is carried off undecomposed, unless you proceed very gently. If due care be taken that the decomposition proceed more slowly, nitrous acid first comes over: if the fire be continued or increased, ammonia is next evolved; and lastly, if the fire be urged, a portion of oxide of arsenic sublimes in the form of a white powder, and a vitreous mass remains in the retort, which powerfully attacks and corrodes it. This is arsenic acid. The chlorate of potash also by oxidizing the arsenious acid converts it into arsenic acid, which, by the assistance of heat, is incapable of decomposing the muriate of potash that remains.

Arsenious acid is used in numerous instances in the arts, under the name of white arsenic, or of arsenic only. In many cases, it is reduced, and acts in its metallic state.

Many attempts have been made to introduce it into medicine; but as it is known to be one of the most violent poisons, it is probable that the fear of its bad effects may deter from its use.

An arseniate of potash was exclusively used by the late Dr. Fowler, of York, who published a treatise on its use in intermittent and remittent fevers. In fact, in this as in many other cases, this remedy had first got into use amongst the empirics and was afterwards adopted by the faculty. This medicine has also been found very useful in the relief of periodical head achs, and as a tonic in nervous and other disorders. Great precaution, however, must be used in preparing and administering it. Externally it has been used as a caustic to extirpate cancer, and is then combined with sulphur, with bole, with antimony, and with the leaves of crow-foot, but it is always accompanied with pain, and is also in some degree dangerous. Febure's remedy was water one pint, extract of hemlock one ounce, Goulard's extract three ounces, tincture of opium one drachm, arsenious acid ten grains. With this the cancer was wetted morning and evening. At the same time a small quantity of a weak solution was administered internally. A milder application of this kind has been made from a solution of one grain in a quart of water, formed into a poultice with crumb of bread.

This being a most dreadful poison, and giving little taste when diffused in water or other vehicles, it is of importance to be well acquainted with the phenomena,

The symptoms of a dangerous dose of arsenic have been graphically represented by Dr. Black: "The symptoms produced by a dangerous dose of arsenic begin to appear in a quarter of an hour, or not much longer, after it is taken. First sickness, and great distress at stomach, soon followed by thirst, and burning heat in the bowels. Then come on violent vomiting, and severe colic pains, and excessive and painful purging. This brings on faintings, with cold sweats, and other signs of great debility. To this succeed painful cramps, and contractions of the legs and thighs, and extreme weakness, and death." Similar results have followed the incautious sprinkling of schirrous ulcers with powdered arsenic, or the application of arsenical pastes. The following more minute specification of symptoms is given by Orfila: "An austere taste in the mouth; frequent ptyalism; continual spitting; constriction of the *pharynx* and *œsophagus*, teeth set on edge; hiccups; nausea; vomiting of brown or bloody matter; anxiety; frequent fainting fits; burning heat at the *præcordia*; inflammation of the lips, tongue, palate, throat, stomach; acute pain of stomach, rendering the mildest drinks intolerable; black stools of an indescribable fetor; pulse frequent, oppressed, and irregular, sometimes slow and unequal; palpitation of the heart; *syncope*; unextinguishable thirst; burning sensation over the whole body, resembling a consuming fire; at times an icy coldness; difficult respiration; cold sweats; scanty urine, of a red or bloody appearance; altered expression of countenance; a livid circle round the eye-lids, swelling and itching of the whole body, which becomes covered with livid spots, or with a miliary eruption; prostration of strength; loss of feeling, especially in the feet and hands; delirium; convulsions, sometimes accompanied with an insupportable priapism; loss of the hair; separation of the epidermis; horrible convulsions; and death."

The best remedies against arsenic, received into the stomach, are mucilaginous liquids and milk; sirups and linseed tea are of service. Vomiting should be excited by tickling the fauces with a feather.

ASAFŒTIDA is obtained from a large umbelliferous plant growing in Persia. The root resembles a large parsnip externally, of a black colour: on cutting it transversely, the asafœtida exudes in form of a white thick juice, like cream; which, from exposure to the air, becomes yellower and yellower, and at last of a dark brown colour. It is very apt to run into putrefaction; and hence those who collect it carefully defend it from the sun. The fresh juice has an excessively strong smell, which grows weaker and weaker upon keeping: a single drachm of the fresh fluid juice smells more than a hundred pounds of the dry asafœtida brought to us. The Persians are commonly obliged to hire ships on purpose for its carriage, as scarcely any one will receive it along with other commodities, its stench infecting every thing that comes near it.

The common asafœtida of the shops is of a yellowish or brownish colour, unctuous and tough, of an acrid or biting taste, and a strong disagreeable smell, resembling that of garlic. From four ounces Neumann obtained, by rectified spirit, two ounces six drachms and a half of resinous extract; and afterward, by water, three drachms and half a scruple of gummy extract, about six drachms and a scruple of earthy matter remaining undissolved. On applying water at first, he gained, from four ounces, one ounce three scruples and a half of gummy extract.

Asafœtida is administered in nervous and hysteric affections, as a deobstruent, and sometimes as an anthelmintic. A tincture of it is kept in the shops, and it enters into the composition of the compound galbanum pill of the London college, the gum pill of former dispensatories.

ASBESTOS OR ASBESTUS is a mineral which has attained celebrity from its resisting fire.

The ancients manufactured cloth out of the fibres of asbestos, for

the purpose, it is said, of wrapping up the bodies of the dead, when exposed on the funeral pile. Several moderns have likewise succeeded in making this cloth; the chief artifice of which seems to consist in the admixture of flax and a liberal use of oil; both which substances are afterwards consumed by exposing the cloth for a certain time to a red heat. Although the cloth of asbestos, when soiled, is restored to its primitive whiteness by heating in the fire; it is found, nevertheless, by several authentic experiments, that its weight diminishes by such treatment. The fibres of asbetos, exposed to the violent heat of the blow-pipe, exhibit slight indications of fusion; though the parts, instead of running together, moulder away, and part fall down, while the rest seem to disappear before the current of air. Ignition impairs the flexibility of asbestos in a slight degree.

There are five varieties of asbestos.

1. Amianthus which occurs in very long, fine, flexible, elastic fibres, of a white, greenish, or reddish colour. It is slightly translucent, is somewhat unctuous to the touch, and has a silky or pearly lustre. It consists of 59 silex, 25 magnesia, 9.5 lime, 3 alumina, and 2.25 oxide of iron. Specific gravity, 1 to 2.3.

2. Common asbestos, fibres of a dull green colour. Specific gravity, 2.7. It is more abundant than amianthus.

3. Mountain leather instead of having parallel fibres like the two preceding, has its fibres interwoven and interlaced so as to be tough. When in thin pieces it is called mountain paper.

4. Mountain cork interlaced like the preceding, but is so light as to swim on water.

5. Mountain wood, of a texture resembling wood. Specific gravity, 2.0.

ASHES. The fixed residue of combustible substances, which remains after they have been burned, is called ashes. In chemistry it is most commonly used to denote the residue of vegetable combustion.

ASPARAGIN. If the juice of asparagus be heated to coagulate the albumen, and then filtered and left to spontaneous evaporation for 15 or 20 days, there will be formed white transparent crystals, of a peculiar vegetable principle, in the form of rhomboidal prisms, hard and brittle, having a cool and slightly nauseous taste. Along with the crystals, are also formed others in the shape of needles.

ASPHALTUM. This substance, likewise called bitumen Judaicum, or Jews' Pitch, is a smooth, hard, brittle, black or brown substance, which breaks with a polish, melts easily when heated, and when pure burns without leaving any ashes. It is found in a soft or liquid state on the surface of the Dead Sea, but by age grows dry and hard. The same kind of bitumen is likewise found in the earth in other parts of the world; in China; America, particularly in the island of Trinidad; and some parts of Europe, as the Carpathian hills, France, Neufchatel, &c. Its specific gravity, according to Boyle, is 1.400, to Kirwan, from 1.07 to 1.65. A specimen from Albania, of the specific gravity of 1.205, examined by Mr. Klaproth, was found to be soluble only in oils and in ether. Five parts of rectified oil of petroleum dissolved one of the asphaltum, without heat, in 24 hours. Analyzed in the dry way, 100 grains afforded 32 of bituminous oil, 6 of water faintly ammoniacal, 30 of charcoal, 7½ of silex, 7½ of alumina, ½ of lime, 1¼ oxide of iron, ½ oxide of manganese, and 36 cubic inches of hydrogen gas.

According to Neumann, the asphaltum of the shops is a very different compound from the native bitumen; and varies, of course, in its properties, according to the nature of the ingredients made use of in forming it. On this account, and probably from other reasons, the use of asphaltum, as an article of the materia medica, is almost totally laid aside.

This substance is found abundantly in Chaldea, and was used by the ancient Babylonians as mortar in building. It was also used by the ancient Egyptians in embalming dead bodies.

ASSAY, OR ESSAY. This oper-

ation consists in determining the quantity of valuable or precious metal contained in any mineral or metallic mixture, by analyzing a small part thereof. The practical difference between the analysis and the assay of an ore, consist in this: the analysis, if properly made, determines the nature and quantities of all the parts of the compound; whereas, the object of the assay consists in ascertaining how much of the particular metal in question may be contained in a certain determinate quantity of the material under consideration. Thus, in the assay of gold or silver, the baser metals are considered as of no value or consequence; and the problem to be resolved is simply, how much of each is contained in the ingot or piece of metal intended to be assayed.

To obtain gold and silver in a state of purity, or to ascertain the quantity of alloy it may contain, it is exposed to a strong heat, together with lead, in a porous crucible. This operation is called cupellation, and is performed as follows: the precious metal is put, together with a due proportion of lead, into a shallow crucible, made of burned bones, called a cupel; and the fusion of the metals is effected by exposing them to a considerable heat in a muffle, or small earthen oven, fixed in the midst of a furnace. The lead continually vitrifies, or becomes converted into a glassy calx, which dissolves all the imperfect metals. This fluid glass, with its contents, soaks into the cupel, and leaves the precious metals in a state of purity. During the cupellation, the scoriæ running down on all sides of the metallic mass, produce an appearance called circulation; by which the operator judges whether the process be going on well. When the metal is nearly pure, certain prismatic colours flash suddenly across the surface of the globule, which soon afterward appears very brilliant and clean: this is called the brightening, and shows that the separation is ended.

After gold has passed the cupel, it may still contain either of the other perfect metals, platina, or silver. The former is seldom suspected; the latter is separated by the operations called quartation and parting. Quartation consists in adding three parts of silver to the supposed gold, and fusing them together; by which means the gold becomes at most one-fourth of the mass only. The intention of this is to separate the particles of gold from each other, so that they may not cover and defend the silver from the action of the nitric acid, which is to be used in the process of parting. Parting consists in exposing the mass, previously hammered or rolled out thin, to the action of seven or eight times its weight of boiling nitric acid of a due strength. The first portion of nitric acid being poured off, about half the quantity, of a somewhat greater strength, is to be poured on the remaining gold; and if it be supposed that this has not dissolved all the silver, it may even be repeated a second time. For the first operation an acid of the specific gravity of 1.280 may be used, diluted with an equal quantity of water; for the second, an acid about 1.28 may be taken undiluted. If the acid be not too concentrated, it dissolves the silver, and leaves the gold in a porous mass, of the original form: but, if too strong, the gold is in a powdery form, which may be washed and dried. The weight of the original metal before cupellation, and in all the subsequent stages, serves to ascertain the degree of fineness of the ingot, or ore, of which it is a part.

In estimating or expressing the fineness of gold, the whole mass spoken of is supposed to weigh twenty-four carats of twelve grains each, either real or merely proportional, like the assayer's weights; and the pure gold is called fine. Thus, if gold be said to be 23 carats fine, it is to be understood that, in a mass, weighing 24 carats, the quantity of pure gold amounts to 23 carats.

In such small works as cannot be assayed by scraping off a part, and cupelling it, the assayers endeavour to ascertain its quality or fineness by the touch. This is a method of comparing the colour, and other

properties, of a minute portion of the metal, with those of small bars, the composition of which is known. These bars are called touch-needles; and they are rubbed upon the black basalts, which, for this reason, is called the touchstone. Black flint or pottery will serve the same purpose. Sets of gold needles may consist of—pure gold; pure gold 23½ carats, with half a carat of silver; 23 carats of gold, with one carat of silver; 22½ carats of gold, with 1½ carats of silver; and so on, till the silver amounts to four carats; after which the additions may proceed by whole carats. Other needles may be made in the same manner, with copper instead of silver; and other sets may have the addition consisting either of equal parts silver and copper, or such proportions as the occasions of business require. The examination by the touch may be advantageously employed previous to quartation, to indicate the quantity of silver necessary to be added.

In foreign countries, where trinkets and small work are required to be submitted to the assay of the touch, a variety of needles are necessary; but they are not much used in England. They afford, however, a degree of information which is more considerable than might at first be expected. The attentive assayer not only compares the colour of the stroke made upon the touchstone by the metal under examination, with that produced by his needle; but will likewise attend to the sensation of roughness, dryness, smoothness, or greasiness, which the texture of the rubbed metal excites, when abraded by the stone. When two strokes, perfectly alike in colour, are made upon the stone, he may then wet them with aquafortis, which will affect them differently, if they be not similar compositions; or the stone itself may be made red hot by the fire, or by the blow pipe, if thin black pottery be used; in which case the phenomena of oxidation will differ, according to the nature and quantity of the alloy.

The French government has from time to time caused various experimental inquiries to be made respecting the art of assaying gold, which have thrown much light on this subject, and greatly tend to produce uniformity in the results of the operation. The latest report on this subject may be seen in the Annales de Chimie, vol. vi. p. 64.; which may be consulted for a full account of the experiments and history of former proceedings. The general result is as follows, nearly in the words of the authors:

"Six principal circumstances appear to affect the operation of parting: namely, the quantity of acid used in parting, or in the first boiling; the concentration of this acid; the time employed in its application; the quantity of acid made use of in the reprise, or second operation; its concentration; and the time during which it is applied. From the experiments it has been shown, that each of these unfavourable circumstances might easily occasion a loss of from the half of a thirty-second part of a carat, or two thirty second parts." The writers explain their technical language by observing, that, the whole mass consisting of twenty-four carats, this thirty-second part denotes 1.768th part of the mass. It may easily be conceived, therefore, that if the whole six circumstances were to exist, and be productive of errors falling the same way, the loss would be very considerable.

It is indispensably necessary, that one uniform process should be followed in the assays of gold; and it is a matter of astonishment, that such an accurate process should not have been prescribed by Government for assayers in an operation of such great commercial importance, instead of every one being left to follow his own judgment. The process recommended in the report before us is as follows:—

"Twelve grains of the gold intended to be assayed must be mixed with thirty grains of fine silver, and cupelled with 108 grains of lead. The cupellation must be carefully attended to, and all the imperfect buttons rejected. When the cupellation is ended, the button must be reduced by lamination into a plate of 1½ inch, or rather more, in length, and four or five

lines in breadth. This must be rolled up upon a quill, and placed in a matrass capable of holding about three ounces of liquid, when filled up to its narrow part. Two ounces and a half of very pure aquafortis, of the strength of 20 degrees of Baume's areometer, must then be poured upon it; and the matrass being placed upon hot ashes, or sand, the acid must be kept gently boiling for a quarter of an hour; the acid must then be cautiously decanted, and an additional quantity of 1½ ounce must be poured on the metal, and slightly boiled for twelve minutes. This being likewise carefully decanted, the small spiral piece of metal must be washed with filtered river water, or distilled water, by filling the matrass with this fluid. The vessel is then to be reversed, by applying the extremity of its neck against the bottom of a crucible of fine earth, the internal surface of which is very smooth. The annealing must then be made, after having separated the portion of water which had fallen into the crucible; and, lastly, the annealed gold must be weighed. For the certainty of this operation, two assays must be made in the same manner, together with a third assay upon gold of twenty-four carats, or upon gold the fineness of which is perfectly and generally known.

No conclusion must be drawn from this assay, unless the latter gold should prove to be of the fineness of twenty-four carats exactly, or of its known degree of fineness; for, if there be either loss or surplus, it may be inferred, that the other two assays, having undergone the same operation, must be subject to the same *error*. The operation being made according to this process, by several assayers, in circumstances of importance, such as those which relate to large fabrications, the fineness of the gold must not be depended on, nor considered as accurately known, unless all the assayers have obtained a uniform result, without communication with each other. The authors observe, however, that this identity must be considered as existing to the accuracy of half of the thirty-second part of a carat. For, notwithstanding every possible precaution or uniformity, it very seldom happens that an absolute agreement is obtained between the different assays of one and the same ingot, because the ingot itself may differ in its fineness in different parts of its mass."

The assaying of silver does not differ from that of gold, excepting that the parting operation is not necessary. A certain small portion of the silver is absorbed by the cupel, and the more when a larger quantity of lead is used, unless the quantity of lead be excessive; in which case most of it will be scorified before it begins to act upon the silver. Messrs. Hellot, Tillet, and Macquer, from their experiments made by order of the French Government, have ascertained, that four parts of lead are requisite for silver of eleven pennyweights twelve grains fine, or containing this weight of pure silver, and twelve grains of alloy, in twelve pennyweights; six parts of lead for silver of eleven pennyweights; eight parts lead for silver of ten pennyweights; ten parts lead for silver of nine pennyweights; and so on in the same progression.

ASTRINGENT PRINCIPLE.—The effect called astringency, considered as distinguishable by the taste, is incapable of being defined. It is perceived in the husks of nuts, of walnuts, in green tea, and eminently in the nut gall. This is probably owing to the circumstance that acids have likewise the property of corrugating the fibres of the mouth and tongue, which is considered as characteristic of astringency as it relates to taste; and hence the gallic acid, which is commonly found united with the true astringent principle, was long mistaken for it. Seguin first distinguished them, and, from the use of this principle in tanning skins, has given it the name of *tannin*. Their characteristic differences are, the gallic acid forms a black precipitate with iron; the astringent principle forms an insoluble compound with albumen.

ATHANOR. A kind of furnace, which has long since fallen into

disuse. The very long and durable operations of the ancient chemists rendered it a desirable requisite, that their fires should be constantly supplied with fuel in proportion to the consumption. The athanor furnace was peculiarly adapted to this purpose. Beside the usual parts, it was provided with a hollow tower, into which charcoal was put. The upper part of the tower, when filled, was closely shut by a well-fitted cover; and the lower part communicated with the fire-place of the furnace. In consequence of this disposition, the charcoal subsided into the fire-place gradually, as the consumption made room for it; but that which was contained in the tower was defended from combustion by the exclusion of a proper supply of air.

ATMOMETER, an instrument invented by Professor Leslie, to measure the quantity of exhalation from a humid surface in a given time. See Leslie on Heat and Moisture.

ATMOSPHERE. See AIR.

ATOMIC THEORY. See EQUIVALENTS.

ATTRACTION. See ELECTIVE ATTRACTION.

AUGITE, called Pyroxene by Haüy, is a mineral, consisting of 48 silica, 24 lime, 12 oxide of iron, 8.75 magnesia, 5 alumina, and 1 manganese. Specific gravity 3.3. Melts in a black enamel. Found in volcanic rocks. Large crystals of it are found in basalt.

AURUM FULMINANS, OR FULMINATING GOLD, is obtained by dissolving gold in the nitro-muriatic acid, and afterwards adding ammonia to the solution, when the gold is precipitated. It must be carefully dried. If agitated or crushed it explodes with great violence.

AURUM GRAPHICUM, one of the ores of gold.

AURUM MUSIVUM, OR MOSAICUM, OR MOSAIC GOLD, is used as a pigment for giving a gold colour to small statues, or plaster figures. It is also employed to imitate lapis lazuli, being mixed in melted glass. It is made in the following manner: melt twelve ounces of tin, and add to it three ounces of mercury; triturate this amalgam with seven ounces of sulphur, and three of muriate of ammonia. Put the powder into a matrass, bedded rather deep in sand, and keep it for several hours in a gentle heat; which is afterward to be raised, and continued for several hours longer. If the heat have been moderate, and not continued too long, the golden coloured scaly porous mass, called aurum musivum, will be found at the bottom of the vessel; but if it have been too strong, the aurum musivum fuses to a black mass of a striated texture. This process is thus explained: as the heat increases, the tin, by stronger affinity, seizes and combines with the muriatic acid of the muriate of ammonia; while the alkali of that salt, combining with a portion of the sulphur, flies off in the form of a sulphuret. The combination of tin and muriatic acid sublimes; and is found adhering to the sides of the matrass. The mercury, which served to divide the tin, combines with part of the sulphur, and forms cinnabar, which also sublimes; and the remaining sulphur, with the remaining tin, forms the aurum musivum which occupies the lower part of the vessel. It must be admitted, however, that this explanation does not indicate the reasons why such an indirect and complicated process should be required to form a simple combination of tin and sulphur.

It does not appear that the proportions of the materials require to be strictly attended to. The process of the Marquis du Bullion, as described by Chaptal in his Elements of Chemistry, consists in amalgamating eight ounces of tin with eight ounces of mercury, and mixing this with six ounces of sulphur, and four of muriate of ammonia. This mixture is to be exposed for three hours on a sand heat sufficient to render the bottom of the matrass obscurely red hot. But Chaptal himself found, that if the matrass containing the mixture were exposed to a naked fire, and violently heated, the mixture took fire, and a sublimate was formed in the neck of the matrass,

consisting of the most beautiful aurum musivum in large hexagonal plates.

Aurum musivum has no taste, though some specimens exhibit a sulphureous smell. It is not soluble in water, acids, or alkaline solutions. But in the dry way it forms a yellow sulphuret, soluble in water. It deflagrates with nitre. Bergmann mentions a native aurum musivum from Siberia, containing tin, sulphur, and a small proportion of copper.

According to Berzelius mosaic gold consists of 100 parts tin, and 52.3 sulphur; according to Dr. John Davy of 100 parts tin, and 56.25 sulphur.

AVANTURINE, is a very beautiful variety of quartz rock, containing spangles of mica. It bears a fine polish. It is usually of a reddish brown, and the spangles are of a gold colour. The finest specimens are brought from Spain.

AXE-STONE. This is a species of nephrite or jade, from which it differs in being of a darker green, and having a somewhat slaty texture. The ingenuity of the natives of New Zealand has enabled them to supply the want of iron or other hard metals to form tools by making axes and other instruments, for cutting wood, out of this stone; by means of which they cut out their canoes from trees, and executed many most beautiful pieces of carving. The constituent parts of axestone are 50.5 silica, 31 magnesia, 10 alumina, 5.5 oxide of iron, 2.75 water, and 0.05 oxide of chromium. This stone is found in Switzerland, Saxony, and on the banks of the great river Amazons in South America.

AXINITE, OR THUMERSTONE, is a mineral, sometimes massive but usually in crystals, which resemble an axe in the form and sharpness of their edges; and are of a violet colour, hence called violet schorl. They become electric by heat. They may be melted by the blow-pipe into a black enamel or dark green glass.

AZOTE is the name given to nitrogen gas, one of the component parts of the atmosphere, and is derived from two Greek words signifying destruction of life; this gas not maintaining either life or combustion, which are supported solely from the oxygenous particles. See NITROGEN GAS.

AZURE STONE, OR LAPIS LAZULI, is a valuable mineral, which yields the beautiful unchangeable blue colour called ultra marine. It consists according to Messieurs Clement and Desormes, of 34 silica, 33 alumina, 3 sulphur, and 22 soda, and 8 loss in the analysis. A small portion of iron and of lime are also sometimes met with. This mineral is of a fine azure blue colour; lustre glistening, fine grained uneven fracture. Specific gravity 2.85. In order to prepare the ultra marine; the pieces of this mineral are made red hot in the fire, and then thrown into water in order to facilitate the reduction of them to powder. After being reduced to powder, they are intimately combined with rosin, wax, and fine linseed oil. The whole compound is then put into a linen cloth, and kneaded in hot water; the first water, which usually contains much dirt, is thrown away; the second yields a fine blue; and the third water a blue of an inferior quality. The mode of operation depends on the foreign matter combined with the ultra marine in the lapis lazuli, more readily uniting with the resinous cement by which means the ultra marine is separated in the washing, and poured off along with the water, leaving the foreign matter behind.

AZURITE, OR LAZULITE of Werner and Hauy is found in Stiria, consists of quadrangular crystals of a fine blue colour. It consists of 66 alumina, 18 magnesia, 10 silica, 2.5 oxide of iron, 2 lime.

B

BAIKALITE. The same as Asbestus Tremolite.

BALAS RUBY. See Spinel.

BALANCE. In conducting chemical experiments a balance of the nicest construction is frequently necessary, in order to determine with the most rigorous exactness the quantities of the materials used. The principles of the construction of a balance belong to the science of Mechanics.

BALDWIN'S PHOSPHORUS is prepared by heating nitrate of lime to a dull red heat. When thus exposed to heat, it undergoes watery fusion: the water then evaporates, and the salt fuses. On cooling it concretes into a semi-transparent substance; which is phosphorescent; that is, emits light in the dark.

BALLOON, is the name of the vehicle in which aerial voyages are performed. The description and principle of construction belong to the science of Pneumatics.

Balloon, in chemical apparatus, is a receiver resembling the form of the balloon of the aeronauts.

BALSAMS, are vegetable juices, exuding from trees, consisting of a substance of a resinous nature, combined with benzoic acid, or from which benzoic acid may be obtained, by boiling them with water. They are insoluble in water, but are readily dissolved in ether or alcohol. Some balsams are liquid as Capaiva, opobalsam, Peru, styrax, tolu; others are such as spontaneously become concrete, are benzoin, dragon's blood, and storax.

Balsam of sulphur, is sulphur dissolved in oil.

BARBADOES TAR, is a species of naphtha or petroleum, found in the island of Barbadoes.

BARILLA, or BARILLOR, is an impure soda, obtained by the burning of plants which grow near the sea; chiefly of the genus salsola. Water is poured upon the ashes, which dissolves the soda, and this water being drained off and evaporated, the barilla is produced. The same plants which yield barilla, when they grow near the sea, will not yield it if cultivated far inland. Barilla is obtained on the shores of Italy and the Levant; also near Barcelona in Spain, and it is also made in the marshy districts of La Vendee in France.

Kelp, which is made from the burning of sea weeds, which grow on the rocks, or is thrown in by the tide, is sometimes called British Barilla.

BARIUM. This is the metallic basis of the earth barytes, which Sir Humphry Davy proved to consist of this metal and oxygen. It is obtained by making pure barytes into a paste with water, and putting a globule of mercury in the middle, and then putting this paste into a platinum spoon, and touching the globule with the negative wire, and the platinum with the positive wire of a voltaic battery. By doing this an amalgam is soon formed of mercury and barium. From this amalgam the mercury must be expelled by heat, and the metal barium remains. It is of a dark grey colour, and about twice the weight of water, as it sinks in sulphuric acid.

Oxygen unites with barium in two proportions, the first forming common barytes, and the second a deutoxide of barium.

BARYTES. This is the oxide of barium, already noticed. It is always found combined with sulphuric or carbonic acid. To obtain pure barytes take native carbonate of barytes, reduce it to a fine powder, and dissolve it in a sufficient quantity of diluted nitric acid, evaporate this solution till a pellicle appears, and then suffer it to crystallize in a shallow bason. The salt obtained is nitrate of barytes. Expose this nitrate of barytes to the action of heat in a china cup, or silver crucible, and keep it in a dull red heat for at least one hour, then suffer the vessel to cool and transfer the greenish solid contents, which are pure barytes, into a well stopped bottle. When dissolved in

a small quantity of water and evaporated, it may be obtained in a beautiful crystalline form.

Pure barytes has a stronger affinity than any other body for sulphuric acid, it turns blue tincture cabbage-green, red vegetable colours to violet, and yellow to brown. It is entirely infusible by heat alone, but melts when mixed with various earths. Its specific gravity is 4,000. It changes quickly in the air, swells, becomes soft and falls into a white powder, with the acquisition of about one-fifth of its weight. This slacking is much more active and speedy than that of lime. It combines with phosphorus, which compound decomposes water rapidly. It unites to sulphur by the dry and humid way. It has a powerful attraction for water, which it absorbs with a hissing noise, and consolidates it strongly. It is soluble in twenty times its weight of cold, and twice its weight in boiling water. Its crystals are long four-sided prisms of a satin-like appearance. It is a deadly poison to animals. It is miscible with oil. It is a sure test to detect the presence of sulphuric acid.

BAROLITE. Carbonate of barytes.

BARRAS. The resinous incrustation on the wounds made in fir-trees.

BASALT, is a mineral production, by many geologists supposed to have been produced by the action of fire, and this is the more probable, from its being found abundantly in countries in which volcanoes exist, or where there are evident traces of their having existed at a former period. The earthy structure of basalt, has, however, been considered to be an insuperable objection to this opinion; but Sir James Hall and Mr. Gregory Walt, have proved, by well conducted experiments, that if basalt be fused into a perfect glass it will resume its stony structure if gradually cooled; and infer, therefore, that the stony structure of basalt is no argument against its having formerly been in a state of fusion.

Basalt is distributed over the whole world, and is found no where in greater variety than in Scotland. Its colours are greyish-black, ash-grey, and raven-black; structure granular; lustre dull. It is found in amorphous masses, or in concretions columnar or globular. Specific gravity 3. It may be melted into a black glass.

The most remarkable is the columnar basaltes, which forms immense masses, composed of columns thirty, forty, or more feet in height, and of enormous thickness. Nay, those at Fairhead are two hundred and fifty feet high. These constitute some of the most astonishing scenes in nature, for the immensity and regularity of their parts. The coast of Antrim in Ireland, for the space of three miles in length, exhibits a very magnificent variety of columnar cliffs; and the Giant's Causeway consists of a point of that coast formed of similar columns, and projecting into the sea upon a descent for several hundred feet. These columns are, for the most part, hexagonal, and fit very accurately together; but most frequently not adherent to each other, though water cannot penetrate between them. And the basaltic appearances on the Hebrides Islands on the coast of Scotland, as described by Sir Joseph Banks, who visited them in 1772, are upon a scale very striking for their vastness and variety.

An extensive field of inquiry is here offered to the geological philosopher, in his attempts to ascertain the alterations to which the globe has been subjected. The inquiries of the chemist equally co-operate in these researches, and tend likewise to show to what useful purposes this and other substances may be applied. Bergmann found that the component parts of various specimens of basaltes were, at a medium, 52 parts silex, 15 alumina, 8 carbonate of lime, and 25 iron. The differences seem, however, to be considerable; for Faujas de St. Fond gives these proportions: 46 silex, 30 alumina, 10 lime, 6 magnesia, and 8 iron. The amorphous basaltes, known by the name of rowley rag, the ferrilite of Kirwan, of the specific gravity of 2.748, afforded Dr. Withering 47.5 of silex, 32.5 of alumina,

and 20 of iron, at a very low degree of oxidation probably. Dr. Kennedy, in his analysis of the basaltes of Staffa, gives the following as its component parts: silex 46, alumina 16, oxide of iron 16, lime 9, soda 4, muriatic acid 1, water and volatile parts 5. Klaproth gives for the analysis of the prismatic basaltes of Hasenberg: silex 44.5, alumina 16.75, oxide of iron 20, lime 9.5, magnesia 2.25, oxide of manganese 0.12, soda 2.60, water 2. On a subsequent analysis, with a view to detect the existence of muriatic acid, he found slight indications of it, but it was in an extremely minute proportion.

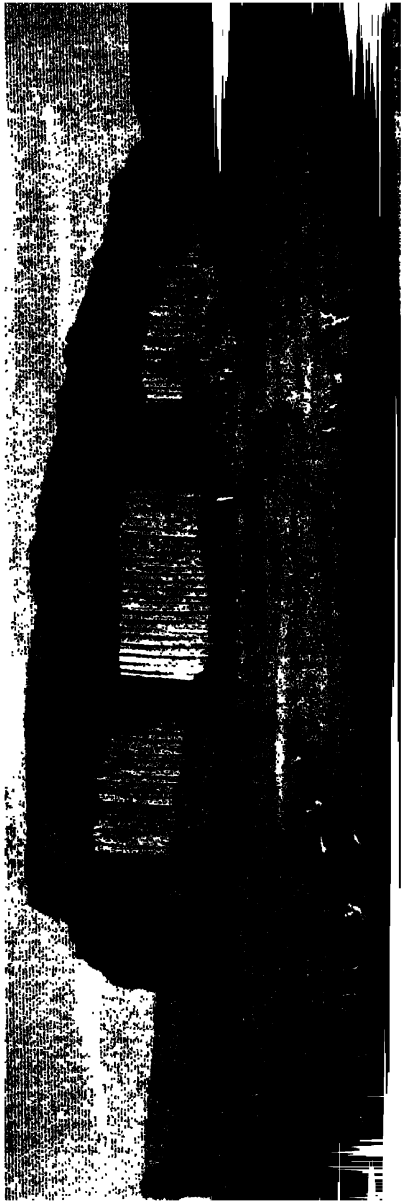
Basaltes, when calcined and pulverized, is said to be a good substitute for puzzolana in the composition of mortar, giving it the property of hardening under water. Wine bottles have likewise been manufactured with it, but there appears to be some nicety requisite in the management to ensure success. Mr. Castelveil, who heated his furnace with wood, added soda to the basaltes to render it more fusible; while Mr. Giral who used pit coal, found it necessary to mix with his basaltes a very refractory sand. The best mode probably would be to choose basaltes of a close fine grain and uniform texture, and to employ it alone, taking care to regulate the heat properly; for if this be carried too high, it will drop from the iron almost like water.

The formation of basalt is still a subject of controversy; but the recent observations of Sir G. Mackenzie in Iceland, and of D'Aubuisson in Auvergne, appear to be conclusive respecting the igneous origin of basaltic rocks, if any thing were wanting in the chain of evidence on this subject. Rocks of trap and basalt, both in solid beds and also arranged in columns like those of Staffa, were observed on the coast of Iceland, and also in the interior, in which the lower parts of the beds and columns contained scoriæ and slags, and empty cavities. He observed also a successive range of beds of basalt, alternating with beds of tufa, the lower parts of which presented the same appearance of the action of fire.

From the situation of these rocks, and from the existence of submarine volcanoes near Iceland, he conceives that these beds of basalt were formed under the sea by the ejection of lava, which flowing over the moist submarine ground, would confine a portion of water beneath the melted mass: this water would be converted into elastic vapour, or steam, which would endeavour to expand; but where the superincumbent pressure of the ocean, or the tenacity of the lava, prevented its escape, it would be compressed, and form cavities, or air bubbles, at the bottom of the melted mass. In other instances, where the fluidity of the lava permitted the steam from below to escape through it, the mass would be compact, and form solid basalt, or green-stone. It might sometimes happen that water would be enclosed in the cavities of the mass, which is found to be the case in some basalt rocks.

Thus, according to the different circumstances of pressure from the depth of the ocean, and the tenacity of the melted mass, porous or vesicular lava, or compact basalt, might be formed from the same eruption; or the mass might be porous below and compact above. When a volcano first breaks out on land, the surface of the earth opens for a considerable space, which at length is choked up with lava and stones, and the eruption is confined to one place, where it forms a cone or mountain. Through such extended fissures, the melted matter was poured out of submarine volcanoes, and spread in every direction over the bottom of the sea, to a limited extent: successive eruptions of a similar kind formed different beds over each other. If a considerable interval of time elapsed between these operations, loose materials with water-worn fragments might be collected upon the lower lava, and constitute a bed of tufa, which would separate it from the upper.

For the formation of basaltic columns, or regular prismatic forms, it appears requisite that the mass



should cool slowly; and it is probable, and almost certain, that all regular basaltic columns have been enveloped with an incrustation of uncrystallized basalt, which defended the internal mass from agitation, and permitted the crystalline arrangement of the particles to take place. Numerous instances might be cited of basaltic hills, in which the interior parts are columnar, and the outer part a confused indeterminate mass. In some instances the lava from submarine volcanoes has cooled suddenly, and formed beds of compact or porous basalt.

Basaltic mountains are frequently isolated and conical, but have sometimes flat tabular summits. When basalt is decomposed, and intermixt with fragments of rock cemented by loose clay, it is called basaltic tufa. Some basalts decompose rapidly, and form productive soils. I have seen a mound formed of basalt that had been got out of a mine by blasting with gun-powder, and which a respectable miner informed me was once extremely hard and resisted the point of the pick; but by exposure to the air for thirty years it was converted into a rich mould, and covered with a luxuriant crop of vegetables. Some very dark-coloured compact basalts and lavas appear to resist the decomposing effects of the atmosphere more powerfully than any stone. The asperities and protuberances on the basaltic rocks in Auvergne are described by D'Aubuisson as preserving all the appearances of the recent action of volcanic fire, and are so fresh, that he says it seems as if the melted matter were still trickling from them, 'ils semblent dégoutter encore.' The antiquity of these rocks is lost in the darkness of past ages, as the volcanoes of Auvergne were anterior to historic records, and probably to the present condition of the globe.

BASALTIC HORNBLENDE is a species of Hornblende found embedded in basalt, and usually occurs in opaque hexagonal crystals of a black colour, and vitreous lustre. It consists of 47 silica, 26 alumina, 8 lime, 2 magnesia, 15 iron. From the quantity of iron contained in this mineral, it some times acts on the magnetic needle.

BASANITE. See FLINTY SLATE.

BASE. When sulphur is burnt, it unites with oxygen gas, and sulphuric acid is produced. In this case sulphur is said to be the *base* of the acid. In the same manner, if any other substance unite with oxygen, and form an acid, that substance is called the *base*. If an acid combine with an alkali, an earth, or a metallic oxide, and form a neutral salt, the alkali, earth, or metallic oxide in this case is said to be the *base* of that salt.

BATH. The heat communicated from bodies in combustion must necessarily vary according to circumstances; and this variation not only influences the results of operations, but in many instances endangers the vessels, especially if they be made of glass. Among the several methods of obviating this inconvenience, one of the most usual consists in interposing a quantity of sand, or other matter, between the fire and the vessel intended to be heated. The sand bath and the water bath are most commonly used; the latter of which was called Balneum Mariæ by the elder chemists. A bath of steam may, in some instances, be found preferable to the water bath. Some chemists have proposed baths of melted lead, of tin, and of other fusible substances. These may perhaps be found advantageous in a few peculiar operations, in which the intelligent operator must indeed be left to his own sagacity.

There are mixtures which may be as conveniently used as simple water in chemical experiments, which do not boil without being raised to a considerably higher temperature than 212° the boiling point of water. Thus a solution of lime in the muriatic acid, may be heated to 252° with the greatest convenience. By merely adding common salt to water until it be saturated, it may be heated to 225° before boiling. The precise boiling point of any liquid is not every day the same, and depends on the pressure of the atmosphere, which is subject to constant variation; the heavier the atmosphere, as indicated by the use of

mercury in the barometer, so much the higher point may water be raised before it boil. The higher above the level of the sea, and consequently the less the pressure of the incumbent air, at so much the lower point of heat water rises in ebullition.

BDELLIUM. A gum resin, supposed to be of African origin. The best bdellium is of a yellowish brown, or dark brown colour, according to its age; unctuous to the touch, brittle, but soon softening, and growing tough betwixt the fingers; in some degree transparent, not unlike myrrh; of a bitterish taste, and a moderately strong smell. It does not easily take flame, and, when set on fire, soon goes out. In burning it sputters a little, owing to its aqueous humidity. Its sp. grav. is 1.371. Alcohol dissolves about three-fifths of bdellium, leaving a mixture of gum and cerasin. Its constituents, according to Pelletier, are 59 resin, 9.2 gum, 30.6 cerasin, 1.2 volatile oil and loss.

BEAN. The kidney beans, the phaseolus vulgaris, yielded to Einhoff in 3840 parts.

Skins	288
Fibrous starchy matter	425
Starch	1380
Vegeto-animal matter mixed with some starch	799
Extract	131
Albumen	52
Mucilage	744
Loss	21
	3840

The vicia faba, a small bean which becomes black as it ripens, yielded to the same chemist an analysis in 3840 parts.

Volatile matter	600
Skins	386
Fibrous starchy matter	610
Starch	1312
Vegeto animal matter	417
Albumen	31
Extract soluble in alcohol	136
Gummy matter	177
Earthy phosphate	37½
Loss	133½
	3840

BEER, a liquor obtained from the fermentation of the infusion of malt. It is chiefly used in the climates where the heat is insufficient to ripen the grape, but is not unknown in warmer climes. Mr. Parke found the art of making malt and beer known in the centre of Africa. It was known to the ancient Egyptians. We learn from Tacitus that the Germans of his time, were not unacquainted with the art of making beer. See ALE.

BEET. The root of the beet affords a considerable quantity of sugar; and has lately been cultivated, for the purpose of extracting it, to some extent in Germany. It is likewise said, that if beet roots be dried in the same manner as malt, after the greater part of their juice is pressed out, very good beer may be made from them.

BELL METAL is composed of a mixture of copper and tin.

BEN (Oil of). This is obtained from the ben nut, by simple pressure. It is remarkable for its not growing rancid in keeping, or at least not until it has stood for a number of years; and on this account it is used in extracting the aromatic principle of such odoriferous flowers as yield little or no essential oil in distillation.

BENZOIC ACID. This acid was first described in 1608, by Blaise de Vigenere, in his Treatise on Fire and Salt, and has been generally known since by the name of flowers of benjamin or benzoin, because it was obtained by sublimation from the resin of this name. As it is still most commonly procured from this substance, it has preserved the epithet of benzoic, though known to be a peculiar acid, obtainable not from benzoin alone, but from different vegetable balsams, venello, cinnamon, ambergris, the urine of children, frequently that of adults, and always, according to Fourcroy and Vauquelin, though Giese denies this, that of quadrupeds living on grass and hay, particularly the camel, the horse, and the cow. There is reason to conjecture that many vegetables, and among them some of the grasses, contain it, and that it passes from them into the urine. Fourcroy and Vauquelin found it combined with potash and lime in the liquor of dunghills, as

well as in the urine of the quadrupeds above mentioned; and they strongly suspect it to exist in the anthoxanthum odoratum, or sweet-scented vernal grass, from which hay principally derives its fragrant smell. Giese, however, could find none either in this grass or in oats.

The usual method of obtaining it affords a very elegant and pleasing example of the chemical process of sublimation. For this purpose a thin stratum of powdered benzoin is spread over the bottom of a glazed earthen pot, to which a tall conical paper covering is fitted: gentle heat is then to be applied to the bottom of the pot, which fuses the benzoin, and fills the apartment with a fragrant smell, arising from a portion of essential oil and acid of benzoin, which are dissipated into the air, at the same time the acid itself rises very suddenly in the paper head, which may be occasionally inspected at the top, though with some little care, because the fumes will excite coughing. This saline sublimate is condensed in the form of long needles, or straight filaments of a white colour, crossing each other in all directions. When the acid ceases to rise, the cover may be changed, a new one applied, and the heat raised: more flowers of a yellowish colour will then rise, which require a second sublimation to deprive them of the empyreumatic oil they contain.

The sublimation of the acid of benzoin may be conveniently performed by substituting an inverted earthen pan instead of the paper cone. In this case the two pans should be made to fit, by grinding on a stone with sand, and they must be luted together with paper dipped in paste. This method seems preferable to the other, where the presence of the operator is required elsewhere; but the paper head can be more easily inspected and changed. The heat applied must be very gentle, and the vessels ought not to be separated till they have become cool.

The quantity of acid obtained in these methods differs according to the management, and probably also from difference of purity, and in other respects of the resin itself. It usually amounts to no more than about one-eighth part of the whole weight. Indeed Scheele says, not more than a tenth or twelfth. The whole acid of benzoin is obtained with greater certainty in the humid process of Scheele: this consists in boiling the powdered resin with lime water, and afterwards separating the lime by the addition of muriatic acid. Twelve ounces of water are to be poured upon four ounces of slaked lime; and, after the ebullition is over, eight pounds, or ninety-six ounces more of water are to be added: a pound of finely-powdered benzoin being then put into a tin vessel, six ounces of the lime-water are to be added, and mixed well with the powder; and afterwards the rest of the lime-water in the same gradual manner, because the benzoin would coagulate into a mass if the whole were added at once. This mixture must be gently boiled for half an hour with constant agitation, and afterwards suffered to cool and subside during an hour. The supernatant liquor must be decanted, and the residuum boiled with eight pounds more of lime-water; after which the same process is to be once more repeated: the remaining powder must be edulcorated on the filter by affusions of hot water. Lastly, all the decoctions, being mixed together, must be evaporated to two pounds, and strained into a glass vessel.

This fluid consists of the acid of benzoin combined with lime. After it is become cold, a quantity of muriatic acid must be added, with constant stirring, until the fluid tastes a little sourish. During this time the last-mentioned acid unites with the lime, and forms a soluble salt, which remains suspended, while the less soluble acid of benzoin, being disengaged, falls to the bottom in powder. By repeated affusions of cold water upon the filter, it may be deprived of the muriate of lime and muriatic acid, with which it may happen to be mixed. If it be required to have a shining appearance, it may be dissolved in a small quantity of boiling water, from which it will separate in silky filaments by cooling. By this process the benzoic acid may be procured from other substances, in which it exists.

As an economical mode of obtain-

ing this acid, Fourcroy recommends the extraction of it from the water that drains from dunghills, cow-houses, and stables, by means of the muriatic acid, which decomposes the benzoate of lime contained in them, and separates the benzoic acid, as in Scheele's process. He confesses the smell of the acid thus obtained differs a little from that of the acid extracted from benzoin; but this, he says, may be remedied, by dissolving the acid in boiling water, filtering the solution, letting it cool, and thus suffering the acid to crystallize, and repeating this operation a second time.

Mr. Accum found the benzoic acid which he obtained from venello pods contaminated with a yellow colouring matter, from which it could not be freed by repeated solutions and crystallizations; but by boiling with charcoal powder, the acid was rendered perfectly pure.

The acid of benzoin is so inflammable, that it burns with a clear yellow flame without the assistance of a wick. The sublimed flowers in their purest state, as white as ordinary writing paper, were fused into a clear transparent yellowish fluid, at the two hundred and thirtieth degree of Fahrenheit's thermometer, and at the same time began to rise in sublimation. It is probable that a heat somewhat greater than this may be required to separate it from the resin. It is strongly disposed to take the crystalline form in cooling. The concentrated sulphuric and nitric acids dissolve this concrete acid, and it is again separated, without alteration, by adding water. Other acids dissolve it by the assistance of heat, from which it separates by cooling, unchanged. It is plentifully soluble in ardent spirit, from which it may likewise be separated by diluting the spirit with water. It readily dissolves in oils, and in melted tallow. If it be added in a small proportion to this last fluid, part of the tallow congeals before the rest, in the form of white opaque clouds. If the quantity of acid be more considerable, it separates in part by cooling, in the form of needles or feathers. It did not communicate any considerable degree of hardness to the tallow, which was the object of this experiment. When the tallow was heated nearly to ebullition, it emitted fumes which affected the respiration, like those of the acid of benzoin, but did not possess the peculiar and agreeable smell of that substance, being probably the sebacic acid. A stratum of this tallow, about one-twentieth of an inch thick, was fused upon a plate of brass, together with other fat substances, with a view to determine its relative disposition to acquire and retain the solid state. After it had cooled it was left upon the plate, and, in the course of some weeks, it gradually became tinged throughout of a bluish green colour. If this circumstance be not supposed to have arisen from a solution of the copper during the fusion, it seems a remarkable instance of the mutual action of two bodies in the solid state, contrary to that axiom of chemistry which affirms, that bodies do not act on each other, unless one or more of them be in the fluid state. Tallow itself, however, has the same effect.

Pure benzoic acid is in the form of a light powder, evidently crystallized in fine needles, the figure of which is difficult to be determined from their smalness. It has a white and shining appearance; but when contaminated by a portion of volatile oil, is yellow or brownish. It is not brittle as might be expected from its appearance, but has rather a kind of ductility and elasticity, and, on rubbing in a mortar, becomes a sort of paste. Its taste is acrid, hot, acidulous, and bitter. It reddens the infusion of litmus, but not syrup of voilets. It has a peculiar aromatic smell, but not strong unless heated. This, however, appears not to belong to the acid; for Mr. Giese informs us, that on dissolving the benzoic acid in as little alcohol as possible, filtering the solution, and precipitating by water, the acid will be obtained pure, and void of smell, the odorous oil remaining dissolved in the spirit. Its specific gravity is 0.667. It is not perceptibly altered by the air, and has been kept in an open vessel twenty years without losing any of its weight. None of the combustible substances have any effect on it; but it may be refined

by mixing it with charcoal powder and subliming, being thus rendered much whiter and better crystallized. It is not very soluble in water. Wenzel and Lichtenstein say four hundred parts of cold water dissolve but one, though the same quantity of boiling water dissolves twenty parts, nineteen of which separate on cooling.

The benzoic acid unites without much difficulty with the earthy and alkaline bases.

The benzoate of barytes is soluble, crystallizes tolerably well, is not affected by exposure to the air, but is decomposable by fire, and by the stronger acids. That of lime is very soluble in water, though much less in cold than in hot, and crystallizes on cooling. It is in like manner decomposable by the acids and by barytes. The benzoate of magnesia is soluble, crystallizable, a little deliquescent, and more decomposable than the former. That of alumina is very soluble, crystallizes in dendrites, is deliquescent, has an acerb and bitter taste, and is decomposable by fire, and even by most of the vegetable acids. The benzoate of potash crystallizes on cooling in little compacted needles. All the acids decompose it, and the solution of barytes and lime form with it a precipitate. The benzoate of soda is very crystallizable, very soluble, and not deliquescent like that of potash, but it is decomposable by the same means. It is sometimes found native in the urine of graminivorous quadrupeds, but by no means so abundantly as that of lime. The benzoate of ammonia is volatile, and decomposable by all the acids and all the bases. The solutions of all the benzoates, when drying on the sides of a vessel wetted with them, form dendritical crystallizations.

Trommsdorf found in his experiments, that benzoic acid united readily with metallic oxides.

From the chemical properties of this acid, it appears to differ from the other vegetable acids in the nature and properties of the principles that constitute its radical. Its odour, volatility, combustibility, great solubility in alcohol, and little solubility in water, formerly occasioned it to be considered as an oily acid; and have led modern chemists to conceive, that it contains a large quantity of hydrogen in its composition, and that it is in the super abundance of this combustible principle its difference from the other vegetable acids consists. Its solubility in the powerful acids, and its subsequent separation, indicate that its principles are not easily separable from each other. Attempts have been made to decompose it by repeated abstraction of nitric acid: the nitric acid rises first, scarcely altered except toward the end of the process, when nitrous gas comes over; and the acid of benzoin is afterwards sublimed with little alteration. By repeating the process, however, it is said to become more fixed, and at length to afford a few drops of an acid resembling the oxalic in its properties.

The benzoic acid is occasionally used in medicine, but not so much as formerly; and enters into the composition of the camphorated tincture of opium of the London college, heretofore called paregoric elixir.

According to Berzelius its component parts are

Hydrogen . . .	5.16
Carbon	74.41
Oxygen	20.43
	100

BENZOIN or BENJAMIN is a balsam soluble in ether, sulphuretic and acetic acids, and solutions of potash and soda. Ammonia will dissolve a small portion of it, but nitric acid acts very powerfully, and a portion of artificial tannin is produced.

BERGMANNITE. A mineral found in quartz and felspar at Fredericks-warn, in Norway.

BERYL is a very beautiful precious stone, most commonly green, of various shades, passing into honey-yellow and sky-blue. It differs from the emerald in colour, and is also harder: it has been called greenish-yellow emerald, and aqua marine. It consists according to the analysis of Vauquelin of 68 silica, 15 alumina, 14 glucina, 1 oxide of iron, and 2 lime. It is crystallized in hexaedral prisms deeply striated longitu-

dinally, or in 6 and 12 sided prisms, terminated by a 6 sided pyramid. Specific gravity 2.7. The valuable stones found at Cairngorm, Aberdeenshire, are of this mineral.

BEZOARS are concretions, sometimes of very large magnitude found in the stomachs of animals. The word is of Persian origin, and signifies an antidote to poison, which these concretions were supposed to be, and accordingly obtained a celebrity in medicine which they did not deserve. The French chemists on analysing bezoars, found them to consist of eight different kinds. 1. Superphosphate of lime, found in many mammalia. 2. Phosphate of magnesia. 3. Phosphate of ammonia and magnesia found in elephants, horses, &c. 4. Biliary, found in the gall bladder of oxen. This bezoar consists of inspissated bile. It furnishes an orange-yellow paint. 5. Resinous, composed of bile and resin in concentric layers. They are fusible, smooth, soft, and finely polished. The oriental bezoars obtained from unknown animals are of this sort. 6. Fungous, consisting of boletus igniarius or touchwood, swallowed by the animal. 7. Hairy, consisting of hair concreted with other matter. 8. Ligneous, of woody fibre agglomerated; some bezoars sent from Persia in a present to Buonaparte were of this description.

BIHYDROGURET OF CARBON. See CARBURETTED HYDROGEN.

BIHYDROGURET OF PHOSPHORUS. See PHOSPHURETTED HYDROGEN.

BILDSTEIN. See AGALMATOLITE.

BILE. This is a secretion formed in the liver from venous blood. It is an unctuous liquid of a yellowish green colour, and its specific gravity is between 1020 and 1030. Its taste is intensely bitter, and it readily putrifies, exhaling a most nauseous odour.

When the bile of the ox is distilled, it affords about 90 per cent. of insipid water, the residuum is brown, bitter, and may be redissolved in water, it affords traces of uncombined alkali which appears to be soda. The acids render bile turbid and separate from it a substance which possesses many of the properties of albumen. It is likewise coagulated by alcohol, and upon filtering off the clear liquor and evaporating it, an inflamable fusible substance is obtained of an intensely bitter flavour, combined with a portion of soda and bitter salt, this has been termed the resin of bile, and appears to be the principle which confers upon it its chief peculiarities. We should therefore conclude as the result of these observations, that bile consists of water, albumen, soda, a bitter resin, and some minute portions of saline matter.

Biliary calculi are of two kinds, those which most commonly occur are soft, fusible, of a crystalline texture, and inflammable. They have generally been considered as closely resembling spermaceti. They are soluble in boiling alcohol, in ether, and difficultly in oil of turpentine. Chevereuil, having remarked some peculiarities in this substance, is induced to regard it as a peculiar animal principle, and distinguishes it by the name of cholesterine.

The other kind of biliary calculus inspissated bile in appearance, but differs from it in being insoluble in alcohol and water. It is often mixed with variable proportions of the former, constituting biliary calculi of intermediate characters.

BIRDLIME. The best birdlime is made of the middle bark of the holly, boiled seven or eight hours in water, till it is soft and tender; then laid in heaps in pits in the ground and covered with stones, the water being previously drained from it; and in this state left for two or three weeks to ferment till it is reduced to a kind of mucilage. This being taken from the pit is pounded in a mortar to a paste, washed in river water, and kneaded, till it is freed from extraneous matters. In this state it is left four or five days in earthen vessels, to ferment and purify itself, when it is fit for use.

It may likewise be obtained from the mistleto, the viburnum lantana, young shoots of elder, and other vegetable substances.

It is sometimes adulterated with turpentine, oil, vinegar, and other matters.

Good birdlime is of a greenish

colour, and sour flavour; gluey, stringy, and tenacious; and in smell resembling linseed oil. By exposure to the air it becomes dry and brittle, so that it may be powdered; but its viscidity is restored by wetting it. It reddens tincture of litmus. Exposed to a gentle heat it liquefies slightly, swells in bubbles, becomes grumous, emits a smell resembling that of animal oils, grows brown, but recovers its properties on cooling, if not heated too much. With a greater heat it burns, giving out a brisk flame and much smoke. The residuum contains sulphate and muriate of potash, carbonate of lime and alumina, with a small portion of iron.

BISMUTH is a metal of a yellowish or reddish-white colour, little subject to change in the air. It is somewhat harder than lead, and is scarcely, if at all, malleable; being easily broken, and even reduced to powder, by the hammer. The internal face, or place of fracture, exhibits large shining plates, disposed in a variety of positions; thin pieces are considerably sonorous. At a temperature of 480° Fahrenheit, it melts; and its surface becomes covered with a greenish-gray, or brown oxide. A stronger heat ignites it, and causes it to burn with a small blue flame; at the same time that a yellowish oxide, known by the name of flowers of bismuth, is driven up. This oxide appears to rise in consequence of the combustion; for it is very fixed, and runs into a greenish glass when exposed to heat alone.

Bismuth urged by a strong heat in a closed vessel, sublimes entire, and crystallizes very distinctly when gradually cooled.

The sulphuric acid has a slight action upon bismuth, when it is concentrated and boiling. Sulphurous acid gas is exhaled, and part of the bismuth is converted into a white oxide. A small portion combines with the sulphuric acid, and affords a deliquescent salt in the form of small needles.

The nitric acid dissolves bismuth with the greatest rapidity and violence; at the same time that much heat is extricated, and a large quantity of nitric oxide escapes. The solution, when saturated, affords crystals as it cools; the salt detonates weakly, and leaves a yellow oxide behind, which effloresces in the air. Upon dissolving this salt in water, it renders that fluid of a milky white, and lets fall an oxide of the same colour.

The nitric solution of bismuth exhibits the same property when diluted with water, most of the metal falling down in the form of a white oxide, called magistery of bismuth. This precipitation of the nitric solution, by the addition of water, is the criterion by which bismuth is distinguished from most other metals. The magistery or oxide is a very white and subtile powder: when prepared by the addition of a large quantity of water, it is used as a paint for the complexion, and is thought gradually to impair the skin. The liberal use of any paint for the skin seems indeed likely to do this; but there is reason to suspect, from the resemblance between the general properties of lead and bismuth, that the oxide of this metal may be attended with effects similar to those which the oxides of lead are known to produce. If a small portion of muriatic acid be mixed with the nitric, and the precipitated oxide be washed with but a small quantity of cold water, it will appear in minute scales of a pearly lustre, constituting the *pearl powder* of perfumers. These paints are liable to be turned black by sulphuretted hydrogen gas.

The muriatic acid does not readily act upon bismuth.

Alkalis likewise precipitate its oxide; but not of so beautiful a white colour as that afforded by the affusion of pure water.

The gallic acid precipitates bismuth of a greenish yellow, as ferroprussiate of potash does of a yellowish colour.

This metal unites with most metallic substances, and renders them in general more fusible. When calcined with the imperfect metals, its glass dissolves them, and produces the same effect as lead in cupellation; in which process it

is even said to be preferable to lead.

Bismuth is used in the composition of pewter, in the fabrication of printers' types, and in various other metallic mixtures. With an equal weight of lead, it forms a brilliant white alloy, much harder than lead, and more malleable than bismuth, though not ductile; and if the proportion of lead be increased, it is rendered still more malleable. Eight parts of bismuth, five of lead, and three of tin, constitute the fusible metal sometimes called Newton's, from its discoverer, which melts at the heat of boiling water, and may be fused over a candle in a piece of stiff paper without burning the paper. One part of bismuth, with five of lead, and three of tin, forms plumbers' solder. It forms the basis of a sympathetic ink. The oxide of bismuth precipitated by potash from nitric acid, has been recommended in spasmodic disorders of the stomach, and given in doses of four grains four times a-day. A writer in the Jena Journal says he has known the dose carried gradually to one scruple without injury.

Bismuth is easily separable, in the dry way, from its ores, on account of its great fusibility. It is usual, in the processes at large, to throw the bismuth ore into a fire of wood; beneath which a hole is made in the ground to receive the metal, and defend it from oxidation. The same process may be imitated in the small way, in the examination of the ores of this metal; nothing more being necessary, than to expose it to a moderate heat in a crucible, with a quantity of reducing flux; taking care, at the same time, to perform the operation as speedily as possible, that the bismuth may be neither oxidized nor volatilized.

The oxide called the flowers of bismuth, obtained by exposing to a strong heat, is found to consist of 100 parts bismuth, and 11.275 oxygen. The equivalent of oxygen being reckoned, we may easily reckon the equivalent of bismuth from the above analysis; as 11.275 : 100 :: 1 : 8.87. Therefore 8.87 is the equivalent of bismuth, and 9.87 is the equivalent number of this oxide of bismuth.

The substance called the butter of bismuth was formerly obtained by heating this metal with corrosive sublimate. It is now obtained more easily by exposing the metal to chlorine gas. It consists of 33.6 chlorine, and 66.4 metal.

BISTRE is a brown paint obtained by separating the finer parts of wood soot from the grosser by washing. The soot of the beech is said to yield the best bistre.

BITTERN. The mother water which remains after the crystallization of common salt in sea water, or the water of salt springs. It abounds with sulphate and muriate of magnesia, to which its bitterness is owing. See WATER (SEA).

BITTER PRINCIPLE is very extensively diffused in the vegetable kingdom; it is found abundantly in the hop (humulus lupulus), in the common broom (spartium scoparium), in the chamomile (anthemis nobilis), and in quasia, amara and excelsa, in gentian root and columbo. It is obtained from these substances by the action of water, or alcohol and evaporation: it is usually of pale yellow colour; its taste is intensely bitter. It is very soluble both in water, and alcohol, and has little or no action on alkaline acid, saline or metallic solution.

An artificial substance similar to the bitter principle has been obtained by digesting diluted nitric acid on silk, indigo, and the wood of the white willow. This substance has the property of dying cloth of a bright yellow colour. Ammonia deepens this colour. This artificial bitter differs from the natural bitter principle, in its power of combining with the alkalis; in union with the fixed alkalis it constitutes crystallized bodies which have the property of detonating by heat or percussion.

The natural bitter principle is of great importance in the art of brewing, it checks fermentation, and preserves fermented liquors; it is likewise used in medicine.

The bitter principle, like the narcotic principle, appears to con-

sist principally of carbon, hydrogen, and oxygen, with a little azote.

BITTER SPAR, OR RHOMB-SPAR, is a mineral which crystallizes in rhomboids. It consists of 73 carbonate of lime, 25 carbonate of magnesia, and 2 oxide of manganese. It is distinguished from calcareous spar by the peculiarity of its angles which are 106° 15′ and 73° 45′. Specific gravity 2.88.

BITUMEN. This term includes a considerable range of inflammable mineral substances, burning with flame in the open air. They are of different consistency, from a thin fluid to a solid; but the solids are for the most part liquefiable at a moderate heat. The fluid are, 1. Naphtha; a fine, white, thin, fragrant, colourless oil, which issues out of white, yellow, or black clays in Persia and Media. This is highly inflammable, and is decomposed by distillation. It dissolves resins, and the essential oils of thyme and lavender, but is not itself soluble either in alcohol or ether. It is the lightest of all the dense fluids, its specific gravity being 0.708. 2 Petroleum, which is a yellow, reddish, brown, greenish, or blackish oil, found dropping from rocks, or issuing from the earth, in the duchy of Modena, and in various other parts of Europe and Asia. This likewise is insoluble in alcohol, and seems to consist of naphtha, thickened by exposure to the atmosphere. It contains a portion of the succinic acid. 3. Barbadoes tar, which is a viscid, brown, or black inflammable substance, insoluble in alcohol, and containing the succinic acid. This appears to be the mineral oil in its third state of alteration. The solid are, 1 Asphaltum, mineral pitch, of which there are three varieties: the cohesive; the semi compact, maltha; the compact, or asphaltum. these are smooth, more or less hard or brittle, inflammable substances, which melt easily, and burn without leaving any or but little ashes, if they be pure. They are slightly and partially acted on by alcohol and ether. 2. Mineral tallow, which is a white substance of the consistence of tallow, and as greasy, although more brittle. It was found in the sea on the coasts of Finland, in the year 1736; and is also met with in some rocky parts of Persia. It is near one fifth lighter than tallow; burns with a blue flame, and a smell of grease, leaving a black viscid matter behind, which is more difficultly consumed. 3. Elastic bitumen, or mineral caoutchouc, of which there are two varieties. Beside these, there are other bituminous substances, as jet and amber, which approach the harder bitumens in their nature; and all the varieties of pit-coal, and the bituminous schistus, or shale, which contain more or less of bitumen in their composition. See the different kinds of bitumen and bituminous substances, in their respective places in the order of the alphabet.

BITUMINOUS LIMESTONE is known from other limestone by its unpleasant smell when rubbed, which arises from its containing a very minute portion of bitumen. It is of a brown black colour. It is found near Bristol, and in Galway in Ireland. There is a bituminous limestone called Dalmatian, which contains so much bitumen that it may be cut like soap with a knife. It is used for polishing houses. After the walls are built fire is applied by which means they are reduced to a white colour.

BLACK JACK. An ore of zinc, so named by the miners, which is also called blende or mock lead.

BLACK LEAD, OR PLUMBAGO, also called GRAPHITE, consists of 91 parts carbon, and 9 iron. In Borrodale in Cumberland it occurs in beds of varying thickness, and affords a valuable object of commerce. The finer kinds are boiled in oil, and then cut to make pencils. Grates are blackened with it; and it is also used to make crucibles, which stand the fire well.

BLEACHING is the art by which the dark colours are discharged from cloth, and it is rendered white.

BLENDE. See BLACK JACK.

BLOOD. The fluid which first presents itself to observation when the parts of living animals are divided or destroyed, is the blood, which circulates with considerable

velocity through vessels, called veins and arteries, distributed into every part of the system.

Recent blood is uniformly fluid, and of a saline taste. Under the microscope, it appears to be composed of a prodigious number of red globules, swimming in a transparent fluid. After standing for a short time, its parts separate into a thick red matter, or crassamentum, and a fluid called serum. If it be agitated till cold, it continues fluid; but a consistent polypous matter adheres to the stirrer, which by repeated ablutions with water becomes white, and has a fibrous appearance; the crassamentum becomes white and fibrous by the same treatment. If blood be received from the vein into warm water, a similar filamentous matter subsides, while the other parts are dissolved. Alkalis prevent the blood from coagulating; acids, on the contrary, accelerate that effect. In the latter case, the fluid is found to contain neutral salts, consisting of the acid itself, united with soda, which consequently must exist in the blood, probably in a disengaged state. Alcohol coagulates blood. On the water bath, blood affords an aqueous fluid, neither acid nor alkaline, but of a faint smell, and easily becoming putrid. A stronger heat gradually dries it, and at the same time reduces it to a mass of about one-eighth of its original weight.

The blood usually consists of 1 part cruor and 3 of serum. The specific gravity of the former is about 1.245. By making a stream of water flow over it, till it becomes colourless, out of 100 parts there will be separated 64 of colouring matter, and 36 of insoluble fibrin will be left behind. A little albumen is sometimes in the cruor. The specific gravity of the serum is about 1.029. According to Berzelius in 1000 parts of serum of the human blood were 905 water, 80 albumen, 6 muriates of soda and potass, 4 lactate of soda with animal matter, 4.1 soda, and phosphate of soda with animal matter. There was the same quantity of water and albumen in bullock's blood, 2.565 muriates of soda and potass, 6.175 lactate of soda with animal matter, 1.52 soda and animal matter, and 4.74 loss.

The blood changes colour by exposure to oxygen, and other gas. It becomes red when it passes through the lungs.

A mixture of the serum of blood and quick-lime has been employed to give a coating of a stone colour to wood, which has no unpleasant smell, dries quickly, and resists the action of the sun and rain. The wood should be first covered with a coating of plaster, and the composition must be used as it is made.

BLOODSTONE. See Calcedony.

BLOW-PIPE. This is an instrument by means of which the most violent heat of furnaces may be produced from the flame of a candle or lamp, when urged upon a small particle of any substance.

This instrument is sold by the ironmongers, and consists merely of a brass pipe about one-eighth of an inch diameter at one end, and the other tapering to a much less size, with a very small perforation for the wind to escape. The smaller end is bended on one side. For philosophical or other nice purposes the blow-pipe is provided with a bowl or enlargement, (vide Plate), in which the vapours of the breath are condensed and detained, and also with three or four small nozzles, with different apertures, to be slipped on the smaller extremity. These are of use when larger or smaller flames are to be occasionally used, because a larger flame requires a large aperture, in order that the air may effectually urge it upon the matter under examination.

There is an artifice in the blowing through this pipe, which is more difficult to describe than to acquire. The effect intended to be produced is a continual stream of air for many minutes, if necessary, without ceasing. This is done by applying the tongue to the roof of the mouth, so as to interrupt the communication between the mouth and the passage of the nostrils; by which means the operator is at liberty to breathe through the nostrils, at the same time that by the muscles of the lips he forces a con-

tinual stream of air from the anterior part of the mouth through the blow-pipe. When the mouth begins to be empty, it is replenished by the lungs in an instant, while the tongue is withdrawn from the roof of the mouth, and replaced again in the same manner as in pronouncing the monosyllable *tut*. In this way the stream may be continued for a long time without any fatigue, if the flame be not urged too impetuously, and even in this case no other fatigue is felt than that of the muscles of the lips.

A wax candle, of a moderate size, but thicker wick than they are usually made with, is the most convenient for occasional experiments; but a tallow candle will do very well. The candle should be snuffed rather short, and the wick turned on one side towards the object, so that a part of it should lie horizontally. The stream of air must be blown along this horizontal part, as near as may be without striking the wick. If the flame be ragged and irregular, it is a proof that the hole is not round or smooth; and if the flame have a cavity through it, the aperture of the pipe is too large. When the hole is of a proper figure and duly proportioned, the flame consists of a neat luminous blue cone, surrounded by another flame of a more faint and indistinct appearance. The strongest heat is at the point of the inner flame.

The body intended to be acted on by the blow pipe ought not to exceed the size of a peppercorn. It may be laid upon a piece of close-grained, well burned charcoal; unless it be of such a nature as to sink into the pores of this substance, or to have its properties affected by its inflammable quality. Such bodies may be placed in a small spoon made of pure gold or silver, or platina.

Many advantages may be derived from the use of this simple and valuable instrument. Its smallness, which renders it suitable to the pocket, is no inconsiderable recommendation. The most expensive materials, and the minutest specimens of bodies, may be used in these experiments; and the whole process, instead of being carried on in an opaque vessel, is under the eye of the observer from beginning to end. It is true, that very little can be determined in this way concerning the quantities of products; but, in most cases, a knowledge of the contents of any substance is a great acquisition, which is thus obtained in a very short time, and will at all events serve to show the best and least expensive way of conducting processes with the same matters in the larger way.

The blow-pipe has deservedly of late years been considered as an essential instrument in a chemical laboratory, and several attempts have been made to facilitate its use by the addition of bellows, or some other equivalent instruments. These are doubtless very convenient, though they render it less portable for mineralogical researches. It will not, here, be necessary to enter into any description of a pair of double bellows fixed under a table, and communicating with a blow-pipe which passes through the table. Smaller bellows, of a portable size for the pocket, have been made for the same purpose. The ingenious chemist will find no great difficulty in adapting a bladder to the blow-pipe, which, under the pressure of a board, may produce a constant stream of air, and may be replenished, as it becomes empty, by blowing into it with bellows, or the mouth, at another aperture furnished with a valve opening inwards.

The chief advantage these contrivances have over the common blow-pipe is, that they may be filled with oxygen gas, which increases the activity of combustion to an astonishing degree. The vapour from alcohol has likewise been employed for this purpose.

After observing what changes are produced on any substance when melted by itself, it will be advantageous to try the same experiment after combining it with various fluxes. The best fluxes are microcosmic salt, which is a compound of phosphoric acid, soda, and ammonia; subcarbonate of soda, which

must be freed from all impurity, especially sulphuric acid; and borax, which must be freed from the water of crystallization.

These are kept powdered in small phials; and when used, a sufficient quantity may be taken up by the moistened point of a knife: the moisture causes the particles to cohere, and prevents them from being blown away when placed on the charcoal. The flux must then be melted to a clear bead, and the substance to be examined placed upon it. It is then to be submitted to the action, first of the exterior, and afterwards of the interior flame, and the following circumstances to be carefully observed:—

1. Whether the substance is dissolved; and, if so,

2. Whether with or without effervescence, which would be occasioned by the liberation of carbonic acid, sulphurous acid, oxygen, gaseous oxide of carbon, &c.

3. The transparency and colour of the glass while cooling.

4. The same circumstances after cooling.

5. The nature of the glass formed by the exterior flame, and

6. By the interior flame.

7. The various relations to each of the fluxes.

It must be observed that soda will not form a bead on charcoal, but with a certain degree of heat will be absorbed. When, therefore, a substance is to be fused with soda, this flux must be added in very small quantities, and a very moderate heat used at first, by which means a combination will take place, and the soda will not be absorbed. If too large a quantity of soda has been added at first, and it has consequently been absorbed, a more intense heat will cause it to return to the surface of the charcoal, and it will then enter into combination.

Some minerals combine readily with only very small portions of soda, but melt with difficulty if more be added, and are absolutely infusible with a larger quantity; and when the substance has no affinity for this flux, it is absorbed by the charcoal, and no combination ensues.

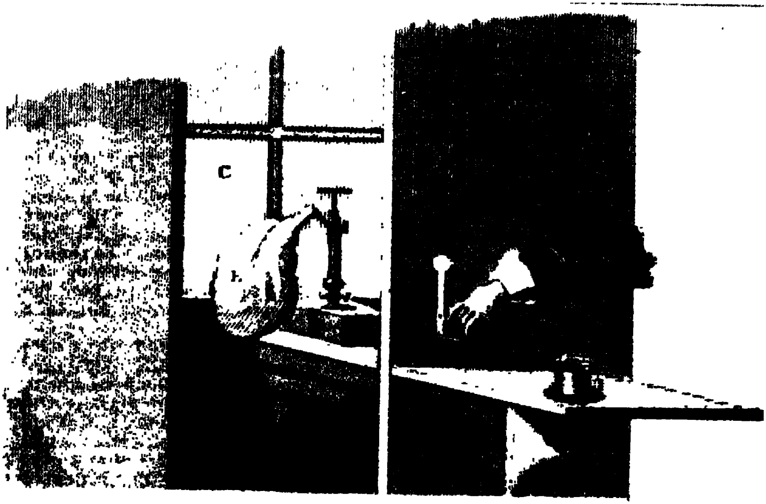
When the mineral or the soda contains sulphur or sulphuric acid, the glass acquires a deep yellow colour, which by the light of a lamp appears red, and as if produced by copper.

If the glass bead becomes opaque as it cools, so as to render the colour indistinct, it should be broken, and a part of it mixed with more of the flux, until the colour becomes more pure and distinct. To render the colour more perceptible, the bead may be either compressed before it cools, or drawn out to a thread.

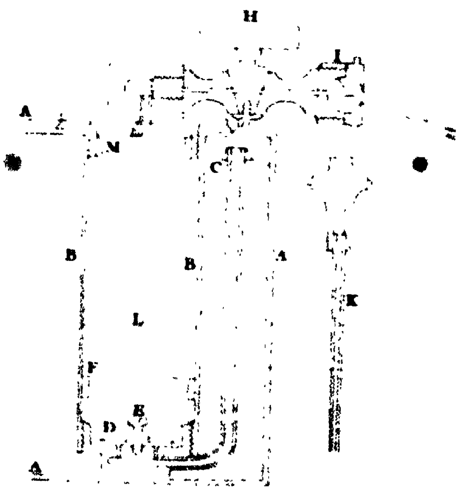
When it is intended to oxidate more highly a metallic oxide contained in a vitrified compound with any of the fluxes, the glass is first heated by a strong flame, and when melted is to be gradually withdrawn from the point of the blue flame. This operation may be repeated several times, permitting the glass sometimes to cool, and using a jet of large aperture with the blowpipe.

The *reduction* of metals is effected in the following manner. The glass bead, formed after the manner already pointed out, is to be kept in a state of fusion on the charcoal as long as it remains on the surface, and is not absorbed, that the metallic particles may collect themselves into a globule. It is then to be fused with an additional quantity of soda, which will be absorbed by the charcoal, and the spot where the absorption has taken place is to be strongly ignited by a tube with a small aperture. By continuing this ignition, the portion of metal which was not previously reduced will now be brought to a metallic state; and the process may be assisted by placing the bead in a smoky flame, so as to cover it with soot that is not easily blown off.

The greatest part of the beads which contain metals are frequently covered with a metallic splendour, which is most easily produced by a gentle, fluttering, smoky flame, when the more intense heat has ceased. With a moderate heat the metallic surface remains; and by a little practice it may generally be known whether the substance un-



Gas Blowpipe



Blowpipe

der examination contains a metal or not. But it must be observed, that the glass of borax sometimes assumes externally a metallic splendour.

When the charcoal is cold, that part impregnated with the fused mass should be taken out with a knife, and ground with distilled water in a crystal, or, what is much better, an agate mortar. The soda will be dissolved; the charcoal will float, and may be poured off; and the metallic particles will remain in the water, and may be examined. In this manner most of the metals may be reduced.

An intense degree of heat was produced by Dr. Robert Hare, of Philadelphia, by directing on different bodies a jet of flame, consisting of oxygen and hydrogen gases, in the proportion in which they form water. The gases were kept in separate gasometers, and only united at the orifice of very small diameter where their tubes terminated.

It remains now for us to describe one of the most generally useful instruments to be operated with, in the whole practice of chemistry. This is the *oxy-hydrogen blow-pipe*, (charged with one part of oxygen, and two of hydrogen gas,) which is capable of obtaining the highest temperatures, and of fusing the most refractory substances.

Description of the oxy-hydrogen blow-pipe.

The figure in the plate represents this instrument in action.

A, B, is a deal screen one inch and a quarter thick, reaching from the floor to the ceiling of the laboratory; it is so constructed, that A opens as a door, whilst B remains fixed. C is the pump for exhausting the common air, and condensing the gases, by means of a piston. D is the metallic box of the blow-pipe, for containing the condensed mixed gases. E is the bladder, containing the gaseous mixture for compression. F is the hand of the operator upon the stop cock of the jet, on the out-side of the screen. G, H, is a glass or brass tube for the jet. I is the spirit-lamp for igniting the gases.

The following is a figure of the minute parts of the blow-pipe.

A, A, A, is the box for the gases. B, B, is a piece of brass tube, closed at the bottom, called the trough, which is fixed air-tight, into the box. C is a small tube in the interior, which, commencing near the top, is inserted into the bottom of the trough; two or four holes are made from the trough into this tube, and open a communication to the gases in the box. D is a circular flat valve, lined with oiled silk or leather. E is a central pin, which covers the holes, and prevents the passage of any thing from the trough into the box. F is an intersection of the trough by fine wire-gauze. G is a small chamber, (in the cap of the trough, which screws on air-tight,) communicating by a fine tube with the interior of the trough; and just below the orifice of this tube is a second piece of very fine wire-gauze. H is the stop-cock, which connects the cap with a jet pierced, having a circular motion, I, and to this, various tubes, as K, may be fitted. A piece of fine wire-gauze covers the end of the tube at C, to stop the passage of any thing from the box, which may prevent the action of the valve.

The mode of rendering the use of this instrument safe, is to reject all jets but such as are of a very fine bore; these being attended with little or no danger, as the flame is arrested in them, by the minute diameter of their passages. On the contrary, when jets of large diameters are used, they are very liable to a recession of the flame into the box, and, consequently, to the complete destruction of the apparatus, and the hazard of the operator's life. But as extremely high temperatures are sometimes necessary for the fusion of refractory bodies, tubes of one-sixtieth of an inch in diameter are absolutely necessary. To prevent injury to the operator, when these tubes are used, Dr. Clarke, of Cambridge, has invented a safety screen, through which the jet passes to the body under operation; and we are happy to add, that the invention has hitherto completely answered its purpose.

When the instrument is to be used, the reservoir should be exhausted of the common air, by means of the syringe, and then filled with the gases; after which, water should be poured into the trough to about I; the gases may then be condensed into the box, by applying the piston vertically; and by their own elastic force, they will pass through the tube, the water, and the various screens of wire-gauze, and issue out at the jet.

When the inflammation, by the use of a very large jet, or of a slow current through a small one, passes backwards, it is generally arrested by the screen at M; and when it does pass it, it merely explodes the small portion of gas in the upper part of the trough, and does no harm; and the valve D prevents the water from being propelled into the box.

Dr. Clarke, in a letter to Dr. Thomson, says, that in using the gas blow-pipe, two precautions are necessary:—First, the operator, before igniting the gas, should apply his ear to the apparatus, gently turning the stop-cock of the jet at the same time,) and listen to determine, by the bubbling noise of the oil, whether it be actually within the safety cylinder. The oil may be drawn into the reservoir whenever the piston is used, if the stop cock below the piston be not carefully shut, before the handle is raised. If there have been a partial detonation in the safety cylinder, as sometimes happens, when the gas is nearly expended, this precaution is doubly necessary, to ascertain whether the oil has not been driven into the reservoir, because an explosion of the whole apparatus would be extremely probable. Using this precaution, the diameter of the jet may be so enlarged as to equal one-twenty fifth of an inch.

Secondly, if, with this diameter, the heat of the flame be not sufficient to melt a platinum wire, whose diameter equals one sixteenth of an inch, the operator may be assured his experiments will not be attended with accurate results. The melting of platinum-wire ought to be considered as a necessary trial of the intensity of the heat, which should be such, that this wire not only falls in drops before the flame, but also exhibits a lively scintillation, resembling the combustion of iron-wire exposed to the same temperature.

"It must," he says, "have appeared very remarkable, that while the reduction of the earths to the metallic state, (and particularly of barytes,) was so universally admitted by all who witnessed my experiments with the gas blow-pipe in Cambridge; the experiments which took place at the Royal Institution for the express purpose of obtaining the same results, totally failed. This will, however, appear less surprising, when it is added, that my own experiments began, at length, to fail also. In the month of April, 1817, owing to causes I could not then explain, the intensity of the heat was so much diminished in the flame of the ignited gases, that I was sometimes unable to effect the fusion of platinum-wire, of the thickness of a common knitting-needle. The blame was, of course, imputed to some impurity, or want of due proportion in the gaseous mixture; when, to our great amazement, the intensity of the heat was again restored, simply by removing a quantity of oil which had accumulated in the cap of the safety-cylinder, and which had acquired a black colour. About this time Dr. Wollaston arrived at Cambridge, and was present at some experiments, in company with the Dean of Carlisle and our professor of chemistry. Dr. Wollaston brought with him some pure barytes. It was immediately observed, that with this newly prepared barytes there was no possibility of obtaining any metallic appearance. The barytes deliquesced before the ignited gases, and drops of a liquid caustic matter fell from it. Hence, it became evident, that the failure here, and at the Royal Institution, might be attributed to the same cause; namely, the impurity of the barytes, which proved to be in fact an hydrate; its reduction to the metallic state, before the ignited gas, being thereby rendered impracticable."

In Mr. Hare's (of Philadelphia) blow-pipe, the gases are not in mixture till they are brought together at the point of emission; "consequently," says Mr. Tilloch, "the operator is completely secured against any danger from an explosion; and it must be obvious, that by having two condensing vessels for the gas reservoirs, every result can be obtained, which the united gases from one vessel can possibly yield; for by means of a cock at the efluxion, the gases may be regulated, till any required proportion of mixture or effect is produced."

The following are some of Dr. Clarke's experiments on various substances by the action of the oxy-hydrogen blow-pipe.

Combustion of the carbonaceous substance which floats on pig-iron.—When this substance was brought, *per se*, into contact with the ignited gas, scintillations ensued, resembling the sparks thrown out by the firework, called *a flower-pot*; but on a smaller scale. When placed upon charcoal, the same appearance takes place, until fusion begins, when a bead of metal is formed upon the charcoal; and, as soon as this begins to boil, such a rapid combustion takes place, that the whole of the metal seems to be sent forth in a volume of sparks.

Fusion and combustion of carburet of iron.—Dr. Clarke selected a small fragment, and brought it into contact with the ignited gases; its fusion immediately ensued, being accompanied, at the same time, by that vivid scintillation which was remarked in the preceding experiment, and which denotes the combustion of metallic bodies, especially of iron and platinum. No change of colour was, however, to be observed in the flame; the light, as usual, was intense.

Upon examining the appearance of plumbago after fusion, its surface was covered with innumerable minute globules, some of which were limpid and transparent; others were of a brownish hue; and the larger globules jet black; and seemed to exhibit a dark metallic lustre; but being so exceedingly minute, it was difficult to ascertain their real nature. They sunk in naphtha, disengaging bubbles of gas. Water produced no change in their appearance; they fell rapidly to the bottom, and remained there without alteration.

Reduction of oxide of tin, attended by combustion.—Wood-tin exposed to the ignited gases, communicates a beautiful blue colour, like that of violets, to the flame. This, Dr. Clarke says, has not been before noticed.

If a pair of iron forceps be used as a support, the iron becomes covered with an oxide of tin, of incomparable whiteness. The fusion is rapid; and if the wood-tin be placed upon charcoal, the metal will be revived in a pure and malleable state.

Reduction of oxide of iron, attended by combustion.—In this experiment, Dr. Clarke made use of wood-iron, or fibrous red hæmatite. It was placed upon charcoal, and instantly fused; being reduced to a bead, which began to burn, like iron-wire, by continuance of heat.

Fusion of platinum.—The largest drops which have fallen from melted platinum-wire, when exposed to the utmost heat, weigh ten grains; but Dr. Clarke obtained drops of metal weighing fourteen grains, when the current of gas was diminished so as not to let the metal run off too quickly from the wire. By placing several globules upon a piece of charcoal, and suffering the whole force of the gases to act upon them, the metal is made to boil, and they all run together in one mass. In this way Dr. Clarke has melted more than 200 grains of platinum into a single brilliant metallic globule.

Combustion and volatilization of tellurium.—When tellurium is placed upon charcoal, and acted upon by these gases, it inflames with violence, accompanied by detonation, exhibiting a very beautiful flame. It is then volatilized in the form of a greenish yellow vapour, having a very disagreeable odour.

Combustion and volatilization of selenium.—The action of the ignited gases on this new metal, causes rapid volatilization, and the metal

as it rises gives a beautiful blue colour to the flame; at the same time the vapour has a strong odour of horse-raddish.

Combustion and scintillation of antimony.—If, when this metal is in a state of ebullition on charcoal, it be thrown upon a deal board, or on the floor, it will divide into innumerable fiery globules, which burn with a vivid flame and brilliant scintillation.

Fusion and scintillation of iron and iron filings.—When these were put upon charcoal, and acted upon by the ignited gases, they were speedily in a state of active ebullition, and gave out a most vivid light, accompanied by beautiful scintillations.

Fusion and combustion of copper.—Copper placed upon the charcoal, boiled and burnt rapidly, giving out a delicate green flame.

Combustion of gold.—If a slip of gold be exposed to the action of these gases in a state of ignition, it will burn with a brilliant green flame.

Combustion of silver.—When a piece of silver is put on a piece of charcoal, before the jet of the compound blow-pipe, it burns with a light green flame.

Fusion and combustion of crystallized phosphate of lime.—This salt did not decrepitate. It was phosphorescent, and fused into a black slag; depositing on an iron forceps, a cupreous coloured powder. It scintillated with a reddish-coloured flame. Upon filing the slag, Dr. Clarke observed a globule of white metal, resembling silver, which does not alter by exposure to the air.

Mr. Hare's experiments on earths, &c. with the oxy-hydrogen blow pipe were equally interesting.

Fusion of silex, alumine, and barytes.—Finely powdered silex was moistened with water; it became agglutinated by the heat, and was then perfectly fused into a colourless glass.

Alumine was perfectly fused into a milk-white enamel.

Barytes fused immediately, with intumescence, owing to water; it then became solid and dry; but soon melted again into a perfect globule, or greyish-white enamel.

Fusion of strontites, glucine, and zircon.—Strontites placed upon the charcoal and exposed to the inflamed gases, exhibited the same phenomena; glucine, in a similar situation, was perfectly fused into a white enamel. Zircon, under the same treatment, exhibited a similar appearance.

Fusion of lime.—When the compound flame fell upon lime, the splendour of the light was insupportable to the naked eye; and when viewed through deep coloured glasses, (as, indeed, all the experiments ought to be,) the lime was seen to become rounded at the angles, and gradually to sink, till, in the course of a few seconds, only a small globular protuberance remained, and the mass of supporting lime was also superficially fused at the base of the column, through the space of half an inch in diameter. The protuberance, as well as the contiguous portion of the lime, was converted into a perfectly white and glistening enamel. A magnifying glass discovered a few minute pores, but not the slightest earthy appearance.

Fusion of magnesia.—The escape of water caused the vertex of the cone of magnesia to fly off in repeated flakes, and the top of the frustum that thus remained, gave nearly as powerful a reflection of light as the lime. After a few seconds, the piece being examined by a magnifying glass, no roughness or earthy particles could be perceived on the spot, but a number of glassy smooth protuberances, whose surface was a perfectly white enamel.

Professor Silliman, of Yale College, says, that we may, perhaps, be justified in saying, in future, that the primitive earths are fusible bodies, although not fusible in furnaces,—in the solar focus, nor, (with the exception of alumine and barytes,) even by a stream of oxygen gas directed upon burning charcoal.

Fusion of gun flint.—Gun flint melted with great rapidity: it first became white, and the fusion was attended with ebullition and a se-

paration of numerous small ignited globules, which seemed to burn away, as they rolled out of the current of flame: the product of this fusion was a beautiful splendid enamel.

Fusion of chalcedony, oriental cornelian, and red jasper.—Chalcedony melted rapidly, and gave a beautiful bluish-white enamel, resembling opal.

Oriental cornelian fused with ebullition, and produced a semi-transparent white globule, with a fine lustre.

Red jasper, from the Grampians, was slowly fused with a sluggish effervescence: it gave a greyish-black slag, with white spots.

Fusion of the beryl, and Peruvian emerald.—Beryl melted instantly into a perfect globule, and continued in a violent ebullition, as long as the flame was applied; and when, after the globule became cold, it was heated again, the ebullition was equally renewed: the globule was a glass of a beautiful bluish white colour.

The phenomena exhibited by the emerald of Peru, were similar; only the globule was green, and perfectly transparent.

Fusion and combustion of leucite.—Leucite instantly fused into a perfect transparent white glass; the fusion was attended with strong ebullition, and many ignited globules darted from it, and burnt in the air, or rolled out upon the charcoal, and then burned.

It is probable that these globules were potassium, as this stone contains more than 20 per cent. of potass.

In addition to these and other interesting experiments, Mr. Hare fused porcelain, common pottery, fragments of Hessian crucibles, Wedgewood's ware, various natural clays, as pipe and porcelain clay, fire brick, common brick, and compound rocks, with equal ease.

M. Lampadius, on making use of the gas blow pipe, found the heat, which is produced by the combustion of oxygen with carburetted hydrogen gas procured from coal, to be more intense than that with pure hydrogen.

BLUE (Prussian) is made by mixing one part of the ferro-prussiate of potass, with one part of copperas, and four parts or more of alum, each previously dissolved in water; the Prussian blue consisting of deuto-ferro prussiate of iron mixed with more or less alumina, precipitates. It is afterwards dried on chalk stones in a stove. It is a mass of an extremely deep blue colour, insipid, inodorous, and much denser than water.

BLUE (Saxon). The best Saxon blue colour may be given by the following composition:

Mix one ounce of the best powdered indigo with four ounces of sulphuric acid, in a glass bottle or matrass, and digest it for one hour with the heat of boiling water, shaking the mixture at different times: then add twelve ounces of water to it, and stir the whole well, and when grown cold, filter it.

Mr. Poerner adds one ounce of good dry potash at the end of twenty-four hours, and lets this stand as much longer, before he dilutes it with water. The cloth should be prepared with alum and tartar.

BOG ORES are ores of iron.

BOLE, is a mineral found in wacke and basalt, in Silesia, Hessia, and Sienna in Italy, also in the Giant's Causeway in Ireland. A black variety is found in the trap rocks of the Isle of Sky. Its colours are yellow red, and brownish black, when it is called mountain soap. It adheres to the tongue, has a greasy feel and falls to pieces in water.

BOLOGNIAN STONE, otherwise called Bolognian phosphorus. Lemery reports, that an Italian shoemaker, named Vincenzo Casciarolo, first discovered the phosphoric property of the Bolognian stone. It is the ponderous spar, or native sulphate of barytes.

If it be first heated to ignition, then finely powdered, and made into a paste with mucilage; and this paste, divided into pieces a quarter of an inch thick, and dried in a moderate heat, be exposed to the heat of a wind furnace, by placing them loose in the midst of the charcoal; a pyrophorus will be

obtained, which, after a minute's exposure to the sun's rays, will give light enough in the dark to render the figures on the dial-plate of a watch visible.

BOLETIC ACID, is an acid extracted from the juice of a species of the boletus, called boletus pseudo igniarius. The juice is concentrated to a syrup by a gentle heat, and acted upon by strong alcohol, what remains is dissolved in water. Nitrate of lead is dropped into this solution, when a white precipitate falls, which is to be well washed with water, and decomposed by a stream of sulphuretted hydrogen gas. Two acids will be found in the liquor after filtration and evaporation. One in small quantity, the phosphoric acid; and the other in permanent crystals, called the boletic acid. It consists of four sided prisms of a white colour, permanent in the air.

BOLETUS. A genus of mushroom, of which several species have been chemically analyzed.

1. *Boletus juglandis*, found on walnut trees. In 1260 parts.

Water	1118.30
Fungin	95.08
Animal matter insoluble in alcohol . .	18.00
Osmazome	12.00
Vegetable albumen .	7.20
Fungate of potash . .	6.00
Adipocere	1.20
Oily matter	1.12
Sugar of mushrooms .	0.50
	1260.00

2. *Boletus laricis*, found growing on larch and fir, has a place in foreign pharmacopœias, under the name of agaric. It is white, and on the outside is like friable leather. Its infusion produces red on vegetable blues; resin may be extracted from this boletus, and also benzoic acid.

3. *Boletus igniarius*. See Amadou.

A solution of this boletus is found to contain sulphate of lime, muriate of potass, and a brown extractive matter. Phosphates of lime and magnesia, with some iron are found in the insoluble matter.

4. *Boletus pseudo igniarius* yields water, boletate, phosphate, and acetate of potass, fungic acid, and vegetable albumen.

5. *Boletus viscidus* consists chiefly of animal mucus, which becomes cohesive by heat.

BONE. The bones of men and quadrupeds owe their great firmness and solidity to a considerable portion of the phosphate of lime which they contain. When these are rasped small, and boiled in water, they afford gelatinous matter, and a portion of fat or oil, which occupied their interstices.

Fourcroy and Vauquelin discovered phosphate of magnesia in all the bones they examined, except human bones. The bones of the horse and sheep afford about 1-36th of phosphate of magnesia; those of fish nearly the same quantity as those of the ox. They account for this by observing, that phosphate of magnesia is found in the urine of man, but not in that of animals, though both equally take in a portion of magnesia with their food.

The experiments of Mr. Hatchett show, that the membranous or cartilaginous substance, which retains the earthy salts within its interstices, and appears to determine the shape of the bone, is albumen. Mr. Hatchett observes, that the enamel of tooth is analogous to the porcellanous shells, while mother of pearl approaches in its nature to true bone.

A curious phenomenon with respect to bone is the circumstance of their acquiring a red tinge, when madder is given to animals with their food. The bones of young pigeons will thus be tinged of a rose colour in twenty-four hours, and of a deep scarlet in three days; but the bones of adult animals will be a fortnight in acquiring a rose colour. The bones most remote from the heart are the longest in acquiring this tinge. Mr. Gibson informs us, that extract of logwood too, in considerable quantity, will tinge the bones of young pigeons purple. On desisting from the use of this food, however, the colouring matter is again taken up into the circulation, and carried off, the bones regaining

their natural hue in a short time. It was said by Du Hamel, that the bones would become coloured and colourless in concentric layers, if an animal were fed alternately one week with madder, and one week without; and hence he inferred, the bones were formed in the same manner as the woody parts of trees. But he was mistaken in the fact; and indeed had it been true, with the inference he naturally draws from it, the bones of animals must have been out of all proportion larger than they are at present.

Bones are of extensive use in the arts. In their natural state, or dyed of various colours, they are made into handles of knives and forks, and numerous articles of turnery. There is a manufacture of volatile alkali from bones, the coal of which forms bone black; or, if they be afterwards calcined to whiteness in the open air, they constitute the bone ashes, of which cupels are made, and which, finely levigated, are used for cleaning articles of paste, and some other trinkets, by the name of burnt hartshorn. The shavings of hartshorn, which is a species of bone, afford an elegant jelly; and the shavings of other bones, of which those of the calf are the best, are often employed in their stead.

On this principle, Mr. Proust has recommended an economical use of bones, particularly with a view to improve the subsistence of the soldier. He first chops them into small pieces, throws them into a kettle of boiling water, and lets them boil about a quarter of an hour. When this has stood till it is cold, a quantity of fat, excellent for culinary purposes when fresh, and at any time fit for making candles, may be taken off the liquor. This in some instances amounted to an eighth, and in others even to a fourth, of the weight of the bones. After this the bones may be ground, and boiled in eight or ten times their weight of water, of which that already used may form a part, till about half is wasted, when a very nutritious jelly will be obtained. The boiler should not be of copper, as this metal is easily dissolved by the jelly; and the cover should fit very tight, so that the heat may be greater than that of boiling water, but not equal to that of Papin's digester, which would give it an empyreuma. The bones of meat that have been boiled, are nearly as productive as fresh bones; but Dr. Young found those of meat that had been roasted afforded no jelly, at least by simmering, or gentle boiling.

Calcined bone yielded to Berzelius:—

Phosphate of lime .	81.0
Phosphate of magnesia	1.1
Fluate of lime . . .	3.0
Lime	10.0
Soda	2.0
Carbonic acid . . .	2.0
	100.0

The same chemist found the bones of oxen to yield:—

Cartilage	33.35
Phosphate of lime .	55.35
Fluate of lime . .	3.00
Carbonate of lime .	3.85
Phosphate of magnesia	2.05
Soda	2.45
	100.00

BORACIC ACID. The salt composed of this acid and soda, had long been used both in medicine and the arts under the name borax, when Homberg first obtained the acid separate in 1702, by distilling a mixture of borax and sulphate of iron. He supposed, however, that it was a product of the latter; and gave it the name of *volatile narcotic salt of vitriol, or sedative salt.* Lemery the younger, soon after discovered, that it could be obtained from borax equally by means of the nitric or muriatic acid; Geoffroy detected soda in borax; and at length Baron proved by a number of experiments, that borax is a compound of soda and a peculiar acid. Cadet has disputed this; but he has merely shown, that the borax of the shops is frequently contaminated with copper; and Struve and Exchaquet have endeavoured to prove that the boracic and phosphoric acids are the

same; yet their experiments only show, that they resemble each other in certain respects, not in all.

To procure the acid, dissolve borax in hot water, and filter the solution; then add sulphuric acid by little and little, till the liquid has a sensibly acid taste. Lay it aside to cool, and a great number of small shining laminated crystals will form. These are the boracic acid. They are to be washed with cold water, and drained upon brown paper.

Boracic acid thus procured is in the form of thin irregular hexagonal scales, of a silvery whiteness, having some resemblance to spermaceti, and the same kind of greasy feel. It has a sourish taste at first, then makes a bitterish cooling impression, and at last leaves an agreeable sweetness. Pressed between the teeth, it is not brittle but ductile. It has no smell; but, when sulphuric acid is poured on it, a transient odour of musk is produced. Its specific gravity in the form of scales is 1.479; after it has been fused, 1.803. It is not altered by light. Exposed to the fire it swells up, from losing its water of crystallization, and in this state is called calcined boracic acid. It melts a little before it is red-hot, without perceptibly losing any water, but it does not flow freely till it is red, and then less than the borate of soda. After this fusion it is a hard transparent glass, becoming a little opaque on exposure to the air, without abstracting moisture from it, and unaltered in its properties, for on being dissolved in boiling water it crystallizes as before. This glass is used in the composition of false gems.

Boiling water scarcely dissolves one-fiftieth part, and cold water much less. When this solution is distilled in close vessels, part of the acid rises with the water, and crystallizes in the receiver. It is more soluble in alcohol, and alcohol containing it burns with a green flame, as does paper dipped in a solution of boracic acid.

Neither oxygen gas, nor the simple combustibles, nor the common metals, produce any change upon boracic acid, as far as is at present known. If mixed with finely powdered charcoal, it is nevertheless capable of vitrification; and with soot it melts into a black bitumen-like mass, which however is soluble in water, and cannot easily be burned to ashes, but sublimes in part. With the assistance of a distilling heat it dissolves in oils, especially mineral oils; and with this it yields fluid and solid products, which impart a green colour to spirit of wine. When rubbed with phosphorus it does not prevent its inflammation, but an earthy yellow matter is left behind. It is hardly capable of oxiding or dissolving any of the metals except iron and zinc, and perhaps copper; but it combines with most of the metallic oxides, as it does with the alkalis, and probably with all the earths, though the greater part of its combinations have hitherto been little examined. It is of great use in analyzing stones that contain a fixed alkali.

The boracic acid has a more powerful attraction for lime, than for any other of the bases, though it does not readily form borate of lime by adding a solution of it to lime-water, or decomposing by lime-water the soluble alkaline borates. In either case an insipid white powder, nearly insoluble, which is the borate of lime, is however precipitated. The borate of barytes is likewise an insoluble, tasteless, white powder.

Bergman has observed, that magnesia, thrown by little and little into a solution of boracic acid, dissolved slowly, and the liquor on evaporation afforded granulated crystals without any regular form: that these crystals were fusible in the fire without being decomposed: but that alcohol was sufficient to separate the boracic acid from the magnesia. If however some of the soluble magnesian salts be decomposed by alkaline borates in a state of solution, an insipid and insoluble borate of magnesia is thrown down. It is probable, therefore, that Bergman's salt was a borate of magnesia dissolved in an excess of boracic acid; which acid being taken up by the alcohol,

the true borate of magnesia was precipitated in a white powder, and mistaken by him for magnesia.

The boracic acid may be united with potass, and forms two salts, one of which is neutral, there being no more potass than necessary to saturate the acid; the other containing an excess.

With soda the boracic acid forms two salts, one of which is *borax*, well known in the arts, which contains three times as much soda as is necessary to saturate the acid; and thereby turning vegetable blues to green. The other is a neutral salt, with no more soda than necessary to saturate the boracic acid.

One of the best known combinations of this acid is the native magnesio-calcareous borate of Kalkberg, near Luneberg: the *wurfelstein* of the Germans, *cubic quartz* of various mineralogists, and *boracite* of Kirwan. It is of a greyish white colour, sometimes passing into the greenish white, or purplish. Its figure is that of a cube, incomplete on its twelve edges, and at four of its solid angles; the complete and incomplete angles being diametrically opposite to each other. The surfaces generally appear corroded. It strikes fire with steel, and scratches glass. Its specific gravity is 2.566, as determined by M. Westrumb, who found it to be composed of boracic acid 0.68, magnesia 0.1305, lime 0.11; with alumina 0.01, silex 0.02, and oxide of iron 0.0075, all of which he considers as casual. Its most remarkable property, discovered by Hauy, is, that like the tourmalin it becomes electric by heat, though little so by friction; and it has four electric poles, the perfect angles always exhibiting negative electricity, and the truncated angles positive.

Since the component parts of this native salt have been known, attempts have been made to imitate it by art; but no chemist has been able, by mixing lime, magnesia, and boracic acid, to produce any thing but a pulverulent salt, incapable of being dissolved, or exhibited in the crystallized form, and with the hardness of the borate of Kalkberg.

It has lately been denied, however, that this compound is really a triple salt. Vauquelin, examining this substance with Mr. Smith, who had a considerable quantity, found the powder to effervesce with acids; and therefore concluded the lime to be no essential part of the compound. They attempted, by using weak acids much diluted, to separate the carbonate from the borate; but they did not succeed, because the acid attacked the borate likewise, though feebly. M. Stromager having afterwards supplied Vauquelin with some transparent crystals, which did not effervesce with acids, he mixed this powder with muriatic acid, and, when the solution was effected by means of heat, evaporated to dryness to expel the excess of acid. By solution in a small quantity of cold distilled water, he separated most of the boracic acid; and, having diluted the solution, added a certain quantity of oxalate of ammonia, but no sign of the existence of lime appeared. To ascertain that the precipitation of the lime was not prevented by the presence of the small quantity of boracic acid, he mixed with the solution a very small portion of muriate of lime, and a cloudiness immediately ensued through the whole. Hence he infers, that the opacity of the magnesian borate is occasioned by carbonate of lime interposed between its particles, and that the borate in transparent crystals contains none.

The borate of potash is but little known, though it is said to be capable of supplying the place of that of soda in the arts; but more direct experiments are required to establish this effect. Like that, it is capable of existing in two states, neutral and with excess of base, but it is not so crystallizable, and assumes the form of parallelopipeds.

With soda the boracic acid forms two different salts. One, in which the alkali is more than triple the quantity necessary to saturate the acid, is of considerable use in the arts, and has long been known by

he name of borax; under which ts history, and an account of its properties will be given. The other s a neutral salt, not changing the yrup of violets green, like the borate with excess of base; differing rom it in taste and solubility; rystallizing neither so readily, nor n the same manner; not efflorescent like it; but like it fusible into glass, and capable of being employed for the same purposes. This salt may be formed by saturating the superabundant soda in borax with some other acid, and then eparating the two salts: but it is bviously more eligible, to saturate he excess of soda with an additional portion of the boracic acid tself.

Borate of ammonia forms in mall rhomboidal crystals, easily lecomposed by fire; or in scales, f a pungent urinous taste, which ose the crystalline form, and grow rown on exposure to the air.

It is very difficult to combine the boracic acid with alumina, at least n the direct way. It has been recommended, for this purpose, to add o a solution of borax a solution of sulphate of alumina; but for this process the neutral borate of soda is preferable, since, if borax be employed, the soda that is in excess may throw down a precipitate of alumina, which might be mistaken or an earthy borate.

The boracic acid unites with silex by fusion, and forms with it a solid and permanent vitreous compound. This borate of silex, however, is neither sapid, nor soluble, nor perceptibly alterable in the air; and cannot be formed without the assistance of a violent heat. In the ame manner triple compounds may be formed with silex and borates already saturated with other bases.

The boracic acid has been found n a disengaged state in several akes of hot mineral waters near Monte Rotondo, Berchiaio, and Castellonuovo in Tuscany, in the proportion of nearly nine grains in hundred of water, by M. Hoeffer. M. Mascagni also found it adhering o schistus, on the borders of lakes, f an obscure white, yellow, or reenish colour, and crystallized in the form of needles. He has likewise found it in combination with ammonia.

According to Klaproth the native boracic acid found in Italy, contained:—

Boracic acid	86
Ferruginous sulphate of manganese	11
Sulphate of lime	3
	100

BORACITE. Borate of magnesia contains, according to Vauquelin, 83.6 boracic acid, and 16.6 magnesia. It occurs in gypsum in the Kalkberg, in the duchy of Brunswick. Specific gravity 2.56.

BORAX. The origin of borax was for a long time unknown in Europe. Mr. Grall Abrahamson, however, sent some to Sweden in the year 1772, in a crystalline form, as dug out of the earth in Thibet, where it is called pounnxa, mypoun, and aonipoun: it is said to have been also found in Saxony, in some coal pits.

It does not appear that borax was known to the ancients, their chrysocolla being a very different substance, composed of the rust of copper, triturated with urine. The word borax is found for the first time in the works of Geber.

Borax is not only found in the East, but likewise in South America. Mr. Anthony Carera, a physician, established at Potosi, informs us, that this salt is abundantly obtained at the mines of Riquintipa, and those in the neighbourhood of Escapa, where it is used by the natives in the fusion of copper ores.

The purification of borax by the Venetians and the Hollanders, was for a long time kept secret. Chaptal finds, after trying all the processes in the large way, that the simplest method consists in boiling the borax strongly, and for a long time, with water. This solution being filtered, affords, by evaporation, crystals, which are somewhat foul, but may be purified by repeating the operation.

Purified borax is white, transparent, rather greasy in its fracture, affecting the form of six-sided

prisms, terminating in three-sided or six sided pyramids. Its taste is styptic; it converts syrup of violets to a green; and when exposed to heat, it swells up, boils, loses its water of crystallization, and becomes converted into a porous, white, opaque mass, commonly called Calcined Borax. A stronger heat brings it into a state of quiet fusion; but the glassy substance thus afforded, which is transparent, and of a greenish-yellow colour, is soluble in water, and effloresces in the air. It requires about eighteen times its weight of water to dissolve it at the temperature of sixty degrees of Fahrenheit; but water at the boiling heat dissolves three times this quantity. Its component parts, according to Kirwan, are, boracic acid 34, soda 17, water 47. For an account of the neutral borate of soda, and other compounds of this acid, see BORACIC ACID.

Borax is used as an excellent flux in docimastic operations. It enters into the composition of reducing fluxes, and is of the greatest use in analysis by the blow pipe. It may be applied with advantage in glass manufactories; for when the fusion turns out bad, a small quantity of borax re-establishes it. It is more especially used in soldering; it assists the fusion of the solder, causes it to flow, and keeps the surface of the metals in a soft or clean state, which facilitates the operation. It is scarcely of any use in medicine. Its acid, called sedative salt, is used by some physicians; and its name sufficiently indicates its supposed effects. Mixed with shell lac, in the proportion of one part to five, it renders the lac soluble by digestion in water heated near boiling.

BORON. The boracic acid being decomposed has been found to consist of oxygen, and a base called boron. It must be effected by mixing it intimately with potassium, exposing the mixture to heat, then allowing it to cool, and pouring on water, a precipitate of boron is produced. It is solid, tasteless, inodorous, of a greenish brown colour. Its specific gravity is a little greater than that of water.

BOTANY BAY RESIN exudes spontaneously from the trunk and wounded bark of the acarois resinifera of New Holland. It soon solidifies into pieces of a yellow colour. It melts at a moderate heat, and when kindled emits a fragrant smoke.

BOTRYOLITE, a variety of datholite found in a bed of gneiss near Arendahl in Norway.

BOURNONITE, is a combination of antimony, sulphur, and lead.

BOVEY COAL. This is of a brown or brownish-black colour, and lamellar texture; the laminæ are frequently flexible when first dug, though generally they harden when exposed to the air. It consists of wood penetrated with petroleum or bitumen, and frequently contains pyrites, alum, and vitriol; its ashes afford a small quantity of fixed alkali, according to the German chemists; but according to Mr. Mills, they contain none. By distillation it yields an ill smelling liquor, mixed with volatile alkali and oil, part of which is soluble in alcohol, and part insoluble, being of a mineral nature.

It is found in England, France, Italy, Switzerland, Germany, Iceland, &c.

BOYLE'S FUMING LIQUOR is the hydroguretted sulphuret of ammonia, a combination of hydrogen, sulphur, and ammonia.

BRAIN OF ANIMALS. The brain has long been known to anatomists: but it is only of late years that chemists have paid it any attention. It is a soft white substance, of a pulpy saponaceous feel, and little or no smell. Exposed to a gentle heat, it loses moisture, shrinks to about a fourth of its original bulk, and becomes a tenacious mass of a greenish brown colour. When completely dried, it becomes solid, and friable like old cheese. Exposed to a strong heat, it gives out ammonia, swells up, melts into a black pitchy mass, takes fire, burns with much flame and a thick pungent smoke, and leaves a coal difficult of incineration.

In its natural state, or moderately dried, it readily forms an emulsion by trituration with water, and is not separated by filtration. This solution lathers like soap-suds, but

does not turn vegetable blue colours green. Heat throws down the dissolved brain in a flocculent form, and leaves an alkaline phosphate in solution. Acids separate a white coagulum from it; and form salts with bases of lime, soda, and ammonia. Alcohol too coagulates it.

Caustic fixed alkalis act very powerfully on brain even cold, evolving much ammonia and caloric. With heat they unite with it into a saponaceous substance.

The action of alcohol on brain is most remarkable. When Fourcroy treated it four times in succession with twice its weight of well rectified alcohol, boiling it a quarter of an hour each time, in a long-necked matrass with a grooved stopple, the three first portions of alcohol, decanted boiling, deposited, by cooling, brilliant laminæ of a yellowish-white colour, diminishing in quantity each time. The fourth deposited very little. The cerebral matter had lost ⅝ths of its weight; and by the spontaneous deposition, and the subsequent evaporation of the alcohol, half of this was recovered in needly crystals, large scales, or granulated matter. The other half was lost by volatilization. This crystallized substance, of a fatty appearance, was agglutinated into a paste under the finger; but did not melt at the heat of boiling water, being merely softened. At a higher temperature it suddenly acquired a blackish-yellow colour, and exhaled, during fusion, an empyreumatic and ammoniacal smell. This shews that it is not analogous to spermaceti, or to adipocere; but it seems more to resemble the fat lamellated crystals contained in some biliary calculi, which, however, do not soften at a heat of 234° F. or become ammoniacal and empyreumatic at this temperature, as the crystalline cerebral oil does.

A portion of this concrete oil, separated from the alcohol by evaporation in the sun, formed a granulated pellicle on its surface, of a consistence resembling that of soft soap. It was of a yellower colour than the former, and had a marked smell of animal extract, and a perceptible saline taste. It was diffusible in water, gave it a milky appearance, reddened litmus paper, and did not become really oily, or fusible after the manner of an oil, till it had given out ammonia, and deposited carbon, by the action of fire or caustic alkalis.

A similar action of alcohol on the brain, nerves, and spinal marrow, is observed after long maceration in it cold, when they are kept as anatomical preparations.

Vauquelin found brain to contain in 100 parts:—

Water	80.00
White fatty matter . . .	4.53
Reddish fatty matter . .	0.70
Albumen	7.00
Osmazome	1.12
Phosphorus	1.50
Acids, salts, and sulphur	5.15
	100.00

BRANDY. This well known fluid is the spirit distilled from wine. The greatest quantities are made in Languedoc, where this manufacture, upon the whole so pernicious to society, first commenced. It is obtained by distillation in the usual method, by a still, which contains five or six quintals of wine, and has a capital and worm tube applied. Its peculiar flavour depends, no doubt, on the nature of the volatile principles, or essential oil, which come over along with it, and likewise, in some measure, upon the management of the fire, the wood of the cask in which it is kept, &c. It is said, that our rectifiers imitate the flavour of brandy, by adding a small proportion of nitrous ether to the spirit of malt or molasses. See ALCOHOL.

BRASS. An elegant yellow-coloured compound metal, consisting of copper combined with about one-third of its weight of zinc. The best brass is made by cementation of calamine, or the ore of zinc, with granulated copper.

It is not easy to unite these two metals in considerable proportions by fusion, because the zinc is burnt or volatilized at a heat inferior to that which is required to melt copper; but they unite very well in the way of cementation. In the brass works, copper is gra-

nulated by pouring it through a plate of iron, perforated with small holes and luted with clay, into a quantity of water about four feet deep, and continually renewed: to prevent the dangerous explosions of this metal, it is necessary to pour but a small quantity at a time. There are various methods of combining this granulated copper, or other small pieces of copper, with the vapour of zinc. Calamine, which is an ore of zinc, is pounded, calcined, and mixed with the divided copper, together with a portion of charcoal. These being exposed to the heat of a wind furnace, the zinc becomes revived, rises in vapour, and combines with the copper, which it converts into brass. The heat must be continued for a greater or less number of hours, according to the thickness of the pieces of copper, and other circumstances; and at the end of the process, the heat being suddenly raised, causes the brass to melt, and occupy the lower part of the crucible. The most scientific method of making brass seems to be that mentioned by Cramer. The powdered calamine, being mixed with an equal quantity of charcoal and a portion of clay, is to be rammed into a melting vessel, and a quantity of copper, amounting to two thirds of the weight of calamine, must be placed on the top, and covered with charcoal. By this management the volatile zinc ascends, and converts the copper into brass, which flows into the rammed clay; consequently, if the calamine contain lead, or any other metal, it will not enter into brass, the zinc alone being raised by the heat.

A fine kind of brass, which is supposed to be made by cementation of copper plates with calamine, is hammered out into leaves in Germany; and is sold very cheap in this country, under the name of Dutch gold, or Dutch metal. It is about five times as thick as gold leaf; that is to say, it is about one sixty-thousandth of an inch thick.

BRASSICA RUBRA. The red cabbage deserves the attention of the chemist from its yielding a test both for the acids and alkalis. Dry some leaves at the fire till they become crisp, and then pour hot water upon them, and the infusion produced, which is naturally blue, will turn green with alkalis, and red with acids.

BRAZIL WOOD. The tree that affords this wood, the cæsalpina crista, is of the growth of the Brazils in South America, and also of the Isle of France, Japan, and elsewhere. It is chiefly used in the process of dying. The wood is considerably hard, is capable of a good polish, and is so heavy that it sinks in water. Its colour is pale when newly cut, but it becomes deeper by exposure to the air. The various specimens differ in the intensity of their colour; but the heaviest is reckoned the most valuable. It has a sweetish taste when chewed, and is distinguished from red sanders, or sandal, by its property of giving out its colour with water, which this last does not.

If the brazil wood be boiled in water for a sufficient time, it communicates a fine red colour to that fluid. The residue is very dark coloured, and gives out a considerable portion of colouring matter to a solution of alkali. Alcohol extracts the colour from brazil wood, as does likewise the volatile alkali; and both these are deeper than the aqueous solution. The spirituous tincture, according to Dufay, stains warm marble of a purplish red, which on increasing the heat becomes violet; and if the stained marble be covered with wax, and considerably heated, it changes through all the shades of brown, and at last becomes fixed of a chocolate colour.

The colours produced by this wood are not very permanent.

BREAD is composed of flour, which is the farinaceous matter of grain ground in a mill, and separated from the bran by sifting or bolting. Flour contains a small quantity of mucilaginous saccharine matter, soluble in cold water, much starch, which is scarcely soluble in cold water, but combines with that fluid by heat, and an adhesive grey substance, insoluble in water, alcohol oil, or ether, and resembling

an animal substance in many of its properties. The action of heat and fermentation produces a change on these substances. In order to make bad flour appear white, and to yield a light porous bread, the London bakers add a portion of alum, the larger in quantity according to the inferiority of the flour, which renders the bread very unwholesome to the constitution.

BRECCIA. An Italian term, frequently used by our mineralogical writers to denote such compound stones as are composed of agglutinated fragments of considerable size. When the agglutinated parts are rounded, the stone is called pudding-stone. Breccias are denominated according to the nature of their component parts. Thus we have calcareous breccias, or marbles; and silicious breccias, which are still more minutely classed, according to their varieties.

BREWING. See BEER, ALCOHOL, and FERMENTATION.

BRICK. Among the numerous branches of the general art of fashioning argillaceous earths into useful forms, and afterwards hardening them by fire, the art of making bricks and tiles is by no means one of the least useful.

Common clay is scarcely ever found in a state approaching to purity on the surface of the earth. It usually contains a large proportion of silicious earth. Bergmann examined several clays in the neighbourhood of Upsal, and made bricks, which he baked with various degrees of heat, suffered them to cool, immersed them in water for a considerable time, and then exposed them to the open air for three years. They were formed of clay and sand. The hardest were those into the composition of which a fourth part of sand had entered. Those which had been exposed for the shortest time to the fire were almost totally destroyed, and crumbled down by the action of the air; such as had been more thoroughly burned suffered less damage; and in those which had been formed of clay alone, and were half vitrified by the heat, no change whatever was produced.

On the whole he observes, that the proportion of sand to be used to any clay, in making bricks, must be greater the more such clay is found to contract in burning; but that the best clays are those which need no sand. Bricks should be well burned; but no vitrification is necessary, when they can be rendered hard enough by the mere action of the heat. Where a vitreous crust might be deemed necessary, he recommends the projection of a due quantity of salt into the furnace, which would produce the effect in the same manner as is seen in the fabrication of the English pottery called stone-ware.

A kind of bricks, called fire-bricks, are made from slate-clay, which are very hard, heavy, and contain a large proportion of sand. These are chiefly used in the construction of furnaces for steam-engines, or other large works, and in lining the ovens of glass-houses, as they will stand any degree of heat. Indeed they should always be employed where fires of any intensity are required.

BRICKS (FLOATING.) It appears that a species of brick, which floated in water, was made by the ancients.

BRIMSTONE. Sulphur in hard solid masses is so called. See SULPHUR.

BRIONIA ALBA is a plant which has some cathartic powers, and accordingly was admitted into the pharmacopœia. It is found upon analysis to consist of starch, with a bitter principle, soluble in water and alcohol, some gum, a vegeto-animal matter, precipitable by infusion of galls, some woody fibre, a little sugar, and supermalate and phosphate of lime.

BROCATELLO. A calcareous stone or marble, composed of fragments of four colours, white, grey, yellow, and red.

BRONZE. A mixed metal, consisting chiefly of copper, with a small proportion of tin, and sometimes other metals. It is used for casting statues, cannon, bells, and other articles, in all which the proportions of the ingredients vary.

When tin is melted with copper, it composes the compound called bronze. In this metal the specific

gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The uses of this hard, sonorous, and durable composition, in the fabrication of cannon, bells, statues, and other articles, are well known. Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. See SPECULUM. The ancients made cutting instruments of this alloy. A dagger analyzed by Mr. Hielm consisted of 83$\frac{3}{8}$ copper, and 16$\frac{1}{8}$ tin.

BRONZITE. This mineral has a resemblance in its lustre to bronze. Its specific gravity is 3.2. It is composed of

Silica . . .	60.0
Magnesia . .	29.5
Oxide of iron	10.5
Water . . .	00.5
	100.0

BROWN SPAR, OR SIDEROCALCITE, also called Pearl Spar, is composed of

Carbonate of lime . . .	49.19
Carbonate of Magnesia .	44.39
Oxide of iron	3.40
Manganese	1.50
Loss	1.52
	100.00

BRUCIA, OR BRUCINE, is a new vegetable alkaline. The name of *brucine* has been given from Mr. Bruce, the Abyssinian traveller, having first made known the tree, the false Angustura, or *Brucea antidysentericus*; from the bark of which, the new alkaline substance is obtained. The crystals of brucine, when obtained by slow evaporation, are oblique prisms, the bases of which are parallelograms. When deposited from a saturated solution in boiling water by cooling, it is in bulky plates, somewhat similar to boracic acid in appearance. When in this state, the water may be forced out of it by compression. It is soluble in 500 times its weight of boiling water, and 850 times its weight of cold water. Its taste is exceedingly bitter and acrid, and continues long in the mouth. Given in doses of a few grains, it is poisonous, and acts upon animals in the same way as strychnine. It is not altered by exposure to air; it may be melted by heat at a little above 212°, without decomposition, and thus appears like wax. When exposed to a strong heat it is decomposed. It combines with the acids, and forms neutral and bisalts. All these salts easily crystallize.

The action of brucine on the animal system is analogous to that of strychnine, but compared with it, its force is not more than as 1 to 12. It induces violent attacks of tetanus; it acts on the nerves without attacking the brain, or injuring the intellectual faculties. It required four grains to kill a rabbit; and a dog having taken three grains, suffered severely but overcame the poison. It is suggested that the alcoholic extract of the Angustura bark may be used with advantage in place of the extract of the vomica nut. It appears that this alkali is combined in the bark with gallic acid; the bark contains, besides, a fatty matter, gum, a yellow colouring matter, sugar in very small quantities, and ligneous fibre.

BRUNSWICK GREEN. This is an ammoniaco-muriate of copper, much used for paper-hangings, and on the continent in oil painting. See COPPER.

BUTTER. The oily inflammable part of milk, which is prepared in many countries as an article of food. The common mode of preserving it is by the addition of salt, which will keep it good a considerable time, if in sufficient quantity. Mr. Eaton informs us, in his Survey of the Turkish Empire, that most of the butter used at Constantinople is brought from the Crimea and Kuban, and that it is kept sweet, by melting it while fresh over a very slow fire, and removing the scum as it rises. He adds, that by melting butter in the Tartarian

manner, and then salting it in ours, he kept it good and fine-tasted for two years; and that this melting, if carefully done, injures neither the taste nor colour. Thenard, too, recommends the Tartarian method. He directs the melting to be done on a water-bath, or at a heat not exceeding 180° F.; and to be continued till all the caseous matter has subsided to the bottom, and the butter is transparent. It is then to be decanted, or strained through a cloth, and cooled in a mixture of pounded ice and salt, or at least in cold spring water, otherwise it will become lumpy by crystallizing, and likewise not resist the action of the air so well. Kept in a close vessel, and in a cool place, it will thus remain six months or more, nearly as good as at first, particularly after the top is taken off. If beaten up with one-sixth of its weight of the cheesy matter when used, it will in some degree resemble fresh butter in appearance. The taste of rancid butter, he adds, may be much corrected by melting and cooling in this manner.

Dr. Anderson has recommended another mode of curing butter, which is as follows: Take one part of sugar, one of nitre, and two of the best Spanish great salt, and rub them together into a fine powder. This composition is to be mixed thoroughly with the butter, as soon as it is completely freed from the milk, in the proportion of one ounce to sixteen; and the butter thus prepared is to be pressed tight into the vessel prepared for it, so as to leave no vacuities. This butter does not taste well, till it has stood at least a fortnight; it then has a rich marrowy flavour, that no other butter ever acquires; and with proper care may be kept for years in this climate, or carried to the East Indies, if packed so as not to melt.

In the interior parts of Africa, Mr. Park informs us, there is a tree much resembling the American oak, producing a nut in appearance somewhat like an olive. The kernel of this nut, by boiling in water, affords a kind of butter, which is whiter, firmer, and of a richer flavour, than any he ever tasted made from cows' milk, and will keep without salt the whole year. The natives call it *shea toulou*, or tree butter. Large quantities of it are made every season.

BUTTER OF ANTIMONY. See Antimony.

BUTTER OF CACAO. An oily concrete white matter, of a firmer consistence than suet, obtained from the cacao nut, of which chocolate is made. The method of separating it consists in bruising the cacao and boiling it in water. The greater part of the superabundant and uncombined oil contained in the nut is by this means liquefied, and rises to the surface, where it swims, and is left to congeal, that it may be the more easily taken off. It is generally mixed with small pieces of the nut, from which it may be purified, by keeping it in fusion without water in a pretty deep vessel, until the several matters have arranged themselves according to their specific gravities. By this treatment it becomes very pure and white.

Butter of cacao is without smell, and has a very mild taste, when fresh; and in all its general properties and habitudes, it resembles fat oils; among which it must therefore be classed. It is used as an ingredient in pomatums.

BUTTER OF TIN. See Tin.

BYSSOLITE. A massive mineral, in short and somewhat stiff filaments, of an olive-green colour, implanted perpendicularly like moss, on the surface of certain stones.

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CABBAGE (Red) yields an excellent test to ascertain the presence of acids and alkalis. See Brassica.

CACAO (Butter of) See Cacao.

CACHOLONG. A variety of quartz found in Greenland, Iceland, and the Ferroe Islands. It is not fusible by the blow-pipe. Specific gravity 2,2.

CADMIUM, is a metal which has been discovered in the carbonates and silicates of zinc.

It may be procured by digesting the ore in muriatic acid, by which a mixed muriate of zinc and cadmium is obtained, it should be evaporated to dryness, and re-dissolved in water. If cadmium be present the solution affords a bright yellow precipitate with sulphuretted hydrogen, and upon immersing into it a plate of zinc, metallic cadmium is precipitated, which may be fused into a button in the usual way.

The physical properties of cadmium closely resemble those of tin; its specific gravity is 8.63. It fuses and volatilizes at a temperature a little below that required by tin. Air does not act upon it except when heated, when it forms an orange-coloured oxide, not volatile and easily reducible.

Oxide of cadmium readily dissolves in acids, it is precipitated by potash in the state of a white hydrated oxide soluble in ammonia. Sulphuretted hydrogen forms a yellow precipitate, and zinc throws down metallic cadmium.

Cadmium unites easily with most of the metals, when heated along with them out of contact of air. Most of its alloys are brittle and colourless. That of copper and cadmium is white, with a slight tinge of yellow. Its texture is composed of very fine plates. Tutty usually contains oxide of cadmium.

CAFFEIN is obtained by adding muriate of tin to an infusion of unroasted coffee, and afterwards decomposing the precipitate thus produced by sulphuretted hydrogen. On the surface will be found a liquor of a peculiar bitter, which will occasion a green precipitate in concentrated solutions of iron. If this liquor be evaporated, a substance will be left behind, yellow, and transparent like horn. The solution is an excellent test to ascertain the presence of iron.*

CAJEPUT OIL. The volatile oil obtained from the leaves of the cajeput tree. Cajeputa officinarum, the melaleuca leucadendron of Linnæus. The tree which furnishes the cajeput oil is frequent on the mountains of Amboyna, and other Molucca islands. It is obtained by distillation from the dried leaves of the smaller of two varieties. It is prepared in great quantities, especially in the island of Banda, and sent to Holland in copper flasks. As it comes to us, it is of a green colour, very limpid, lighter than water, of a strong smell, resembling camphor, and a strong pungent taste, like that of cardamons. It burns entirely away, without leaving any residuum. It is often adulterated with other essential oils, coloured with the resin of mil-foil. In the genuine oil, the green colour depends on the presence of copper; for when rectified it is colourless.

CALAMINE, or LAPIS CALAMINARIS, is a native carbonate of zinc, being the principal ore from which that metal is extracted.

CALCAREOUS EARTH is the same as lime, of which there are various combinations, as marble, limestone, marl, gypsum. Calcareous earth exists in immense strata in many countries, and some immense ranges of mountains are composed of it. Vast quantities of marine shells, and the bones of animals, are found embedded in it.

Three fifths of the surface of the globe are covered by the sea, the average depth of which has been estimated at from five to ten miles; but great changes have taken place in the relative position of the present continents with the ocean, which, in former ages, rolled its waves over the summits of our highest mountains.

Of this, demonstrative proofs exist in our own island and in various parts of the world. The calcareous or lime stone mountains in Derbyshire, and Craven in Yorkshire, rise up to the height of about 2000 feet above the present level of the sea. They contain through their whole extent fossil remains of zoophytes, shell fish, and marine animals, but more abundantly in some parts than in others.

Particular species occupy almost exclusively distinct beds, and in some situations the whole mass appears a compact congeries of these

marine organic remains. In Derbyshire the beds of lime-stone are separated by different beds of a stone called toad-stone, varying in thickness from 50 to 150 feet, in which are no organic remains; but we meet with them again whenever we come to the lime-stone either above or below the toad-stone.

The distinct characters which the separate beds in these mountains present, prove that they have not been brought there by any sudden inundation. They must have remained for ages under the ocean prior to their elevation above its surface.

The mountains of the Pyrennees are covered in the highest part at Mont Perdu with calcareous rocks, containing impressions of marine animals; and even where the impressions are not visible in the lime-stone, it yields a fetid cadaverous odour when dissolved in acids, owing, in all probability, to the animal matter it contains. Mont Perdu rises 10,500 feet above the level of the sea; it is the highest situation in which any marine remains have been found in Europe. In the Andes they have been observed by Humboldt at the height of 14,000 feet.

In England, the calcareous mountains contain no remains of vegetables; but, in the thick beds of shale and grit-stone, lying upon them, are found various vegetable impressions, and above these regular beds of coal, with strata containing shells of fresh-water muscles. In the earthy lime-stone of the upper strata are sometimes found fossil flat fish, with impressions of the scales and bones quite distinct; and lastly, in and under the thick beds of clay covering chalk, in the southern counties, the bones of the rhinoceros, the elephant and the mammoth, are not uncommonly discovered.

The sagacious naturalist Cuvier has examined these bones from different parts of the world with much attention, and has observed characteristic variations of structure, which prove that they belong to animals not now existing on our globe: nor have many of the various zoophytes and shell-fish, found in calcareous rocks, been discovered in our present seas.

The fossil remains of animals not now in existence, entombed and preserved in solid rocks, present us with durable monuments of the great changes which our planet has undergone in former ages. We are led to a period when the waters of the ocean have covered the summits of our highest mountains, and are irresistibly compelled to admit one of two conclusions, either that the sea has retired and sunk down below its former level; or some power, operating from beneath, has lifted up the islands and continents, with all their hills and mountains, from the watery abyss, to their present elevation above its surface.

We are also led to infer that great revolutions have taken place at distant periods of time. The inundations which buried vegetables and quadrupeds in distinct separate strata, were subsequent to each other, and were both posterior to the formation of the lime-stone resting upon primary rocks; for different organic remains are not found existing together, except in those stony masses which are formed from the *debris* or fragments of rocks and strata broken down and again consolidated into immense masses and strata.

CALC-SPAR, or CALCAREOUS SPAR, is the carbonate of lime formed into crystals. The forms of the crystals amount to some hundreds. The colours are grey, yellow, red, green, and sometimes blue. The specific gravity is about 2.7. It consists of 43.6 carbonic acid, and 56.4 lime. It may be dissolved in muriatic acid very easily, and it will effervesce with all acids. Some varieties are phosphorescent on hot coals. It is found in the veins of all rocks. Derbyshire produces a great variety of very beautiful specimens of spar.

CALCEDONY is a mineral which has been so named from Calcedon, a town in Asia Minor, where it was anciently found. There are a variety of species. The common calcedony occurs of various colour, white, grey, blue, yellow, green, brown. It consists of very pure silica

with a small addition of water. It is infusible. Specific gravity 2.6. Very fine stalactitical specimens of calcedony have been found in the mines in Cornwall. The sub-species of calcedony, heliotrope, chrysoprase, plasma, onyx, sard, and sardonyx cornelian.

CALC SINTER is a stalactitical carbonate of lime, which is usually formed by the water oozing through the roof of a cavern or a bridge. When there is a superabundance of carbonic acid in lime it is dissolved, but when part of the carbonic acid make its escape, the lime is precipitated, and on the caverns forms the stalactites; and sometimes it drops to the bottom of the cave or cavern, and forms itself into all manner of beautiful phantastic shapes. The grotto of Antiparos, in one of the islands in the Grecian Archipelago, is a very famous instance. The calc sinter hangs usually in pendulous conical rods or tubes, mamellated, massive, and in various shapes. Its lustre is silky.

CALCHANTUM, an expression in Pliny, and means copperas.

CALCINATION. The fixed residues of such matters as have undergone combustion are called cinders in common language, and calces, or now more commonly oxides, by chemists; and the operation, when considered with regard to these residues, is termed calcination. In this general way it has likewise been applied to bodies not really combustible, but only deprived of some of their principles by heat. Thus we hear of the calcination of chalk, to convert it into lime, by driving off its carbonic acid and water; of gypsum or plaster stone, of alum, of borax, and other saline bodies, by which they are deprived of their water of crystallization; of bones, which lose their volatile parts by this treatment; and of various other bodies.

CALCIUM. This is the metallic basis of lime, and was discovered by Sir Humphrey Davy, in the same manner as barium already described. When gently heated it absorbs oxygen and becomes oxide of calcium or lime. Lime is found a native united with carbonic, sulphuric, phosphoric, and fluoric acids, it unites with sulphur, chlorine, anodyne, and phosphorus, in different proportions. See Lime.

CALCULUS. See Bile, and Urinary Calculi.

CALOMEL, a submuriate of mercury much used in medicine.

CALORIC. As most of the operations of nature and of experimental chemistry are effected by means of a change of temperature, a familiar acquaintance with the principal phenomena of heat, besides being in itself most interesting, is necessary to enable to prosecute philosophical inquiry. This subject, as usually treated by chemical writers, is extremely obscure and difficult of comprehension: we have endeavoured to simplify it as much as possible in the following article, originally intended as a part of an elementary treatise on chemistry. The word *heat* has a twofold signification. First, it means that sensation which we experience when we say a thing is hot. For instance, if I touch a tea-pot, with hot water in it, I say, I feel heat. If I put my hand near the fire I feel heat. The word heat also means, that substance or property of bodies which occasions this sensation. Thus we say, there is heat in the water in the tea-pot, and there is heat in the fire. It is with heat, used in this last sense, that we are now concerned. It has often been denominated *caloric*, by way of distinction from the sensation it produces.

Philosophers have found considerable difficulty in determining what was the cause of caloric. Some have imagined that it was not a distinct substance, but was only occasioned by a certain motion of the particles of bodies; and as sound has no distinct existence independent of the motion of bodies which excite the sensation on our nerves, so also they supposed heat was not an independent substance, but arose from the motion of the component particles of bodies. In this opinion they were fortified by observing, that when heat was produced, as in boiling water, there was a motion of the particles, and also that friction, hammering, fermentation, and internal changes of

the particles of bodies produced heat. The more general opinion at present is, that heat is a separate and distinct substance, of extremely minute particles, diffused in different proportions, and in different modifications throughout the other bodies in nature; and there are many experiments and facts which render this opinion very highly probable.

If a blacksmith wish to strike a light, or to make a fire, he has only to take a piece of iron, and hammer it on his anvil, and it soon becomes red-hot. The hammering, it is supposed, forces out the particles of heat, which had formerly been in a dormant state in the iron. This is rendered the more probable from the circumstance that iron so treated cannot be heated in this manner a second time, but if it be heated again in the fire it acquires the properties of giving out heat on being hammered as before. Elastic steel which has the property of recovering its form on being bent or struck, will not produce heat by hammering. Hammered iron becomes more solid, or has greater specific gravity than it had before.

Common air, if suddenly condensed, gives out sufficient heat to light tinder.—A syringe for this purpose is in common use in France, and is also known in this country. The particles of fire are supposed to be forced out by the compression in the same manner as water is forced out by the compression of a sponge.

Friction will produce heat.—The savage Indians make a fire by rubbing two pieces of dry wood together. A fire is sometimes produced in a forest by one branch rubbing into another by the motion produced by the wind. The axle-trees of carriages are often set on fire by the friction: similar accidents may occur in other machines if care be not taken to apply grease or other substances to diminish the friction.

Percussion will produce heat.—Two hard stones struck against one another give out sparks. A knife or even a piece of glass held to a grindstone in motion will do the same. Two swords striking against each other give out sparks. Fire is seen given out from the percussion of the horses' shoes on the stones of the street. A flint and piece of steel is commonly used to light tinder. In the lock of a gun we see the same means employed. So great is the heat produced by these means, that if the sparks which arise from the percussion of flint and steel be received on a piece of white paper, and examined by a microscope, it will be seen, that pieces of the iron have been struck off and melted by the heat, as the particles will be found to be of a round shape.

Whenever two bodies are mixed together, and they unite and occupy less space than they did, then heat is given out.—Measure very exactly some sulphuric acid and also an equal quantity of water, and mix the two together: it will be seen by measurement, that they occupy less room when united. By mixing the two together, great heat is produced considerably above boiling point. In this experiment the particles of the bodies mixed press closely together, and some of the particles of heat are forced out. In dissolving iron, zinc, copper, tin, or any other metal in an acid, the specific gravity being increased, heat is forced out, and becomes very sensible to the touch, or to the thermometer.

Take a piece of quick lime and put it on a plate, and pour on it a little water, and prodigious heat will be felt. If the lime be weighed before the operation, and also afterwards, it will be found that its weight is increased. This arises from the water entering into a solid state in combination with the lime, and it is in the act of becoming solid, that the water gives out this heat. Quick lime is carried from one part to another by sea or by land carriage, in preference to slaked lime, as the weight is greatly increased by the water, which in the operation of slaking enters into combination with it. Should a storm arise at sea, and the ship spring a leak, so that the water in any considerable quantity got access to the lime, sufficient heat would be produced to set the ship on fire, and this has frequently

happened. A very heavy torrent of rain may render it necessary to empty out the lime from a waggon to avoid its being burnt.

There is a striking example of the heat given out by bodies becoming solid, in the churning of milk into butter. At the time the butter is formed great heat is felt.

When the particles of vapour unite and are congealed in the atmosphere, and fall in the form of snow, they give out heat, which is very sensibly felt at such times. As bodies which are condensed lose part of their heat, so also, as the reverse of this, we see that when heat is communicated to bodies their particles remove further asunder, and they occupy more room. Put a long necked bottle, nearly filled with water, into a tea-kettle or saucepan on the fire, and the water in the bottle, as it becomes heated, will rise higher up within the neck of the bottle.

The rise of mercury in the thermometer, by the means of heat, shews this fact.

As heat is forced from bodies, and the sensible temperature is thereby increased when the particles are condensed or brought closer together; so also the reverse of this takes place, that when the particles are made to remove further from each other heat is absorbed, and its sensible indication on the thermometer is diminished. Thus, if a thermometer be put into the receiver of an air-pump, and the air be extracted, it will be seen, after a few strokes of the pump, that the mercury in the thermometer has sunk, and it will continue to do so as the air is more and more extracted. It is evident that when the part of the air is withdrawn by the air pump, the particles remaining in the receiver, still occupying the same space, that is, still filling the receiver, must be further removed from each other, and on the supposition then, that heat is material, there is more room for its particles to arrange themselves amongst the particles of air.

In the same manner it is found, that on ascending into the air in a balloon, that at the same time that the air becomes thinner from its elasticity and having fewer strata above it to press it down, that it also becomes colder. This effect is in like manner experienced on ascending mountains, and as the mercury in the barometer falls and indicates the diminished pressure, so also the descent of the mercury in the thermometer indicates the diminished heat.

The following extract from the writings of Sir H. Davy, will convey the ideas of that great chemist on heat, and they are corroborated by Sir R. Phillips, who has ably discussed this subject in his Twelve Essays on the Proximate Causes of the Material Phenomena of the Universe.

"Calorific repulsion has been accounted for by supposing a subtile fluid capable of combining with bodies, and of separating their parts from each other, which has been named the *matter of heat, or caloric.*

"Many of the phenomena admit of a happy explanation on this idea, such as the cold produced during the conversion of solids into fluids or gases, and the increase of temperature connected with the condensation of gases and fluids.

"But there are other facts which are not so easily reconciled to the opinion. Such are the production of heat by friction and percussion; and some of the chemical changes which have been just referred to." These are the violent heat produced in the explosion of gunpowder, where a large quantity of aeriform matter is disengaged; and the fire which appears in the decomposition of the euchlorine gas, or protoxide of chlorine, though the resulting gases occupy a greater volume.

"When the temperature of bodies is raised by friction, there seems to be no diminution of their capacities, using the word in its common sense; and in many chemical changes, connected with an increase of temperature, there appears to be likewise an increase of capacity. A piece of iron made red-hot by hammering cannot be strongly heated a second time by the same means, unless it has been previously introduced into a fire. This fact has been explained by supposing that

the fluid of heat has been pressed out of it, by the percussion, which is recovered in the fire; but this is a very rude mechanical idea: the arrangements of its parts are altered by hammering in this way, and it is rendered brittle. By a moderate degree of friction, as would appear from Rumford's experiments, the same piece of metal may be kept hot for any length of time; so that if heat be pressed out, the quantity must be inexhaustible. When any body is cooled, it occupies a smaller volume than before; it is evident therefore that its parts must have approached to each other; when the body is expanded by heat, it is equally evident that its parts must have separated from each other. The immediate cause of the phenomena of heat, then, is motion, and the laws of its communication are precisely the same as the laws of the communication of motion." "Since all matter may be made to fill a smaller volume by cooling, it is evident that the particles of matter must have space between them; and since every body can communicate the power of expansion to a body of a lower temperature, that is, can give an expansive motion to its particles, it is a probable inference that its own particles are possessed of motion; but as there is no change in the position of its parts as long as its temperature is uniform, the motion, if it exist, must be a vibratory or undulatory motion, or a motion of the particles round their axes, or a motion of particles round each other.

"It seems possible to account for all the phenomena of heat, if it be supposed that in solids the particles are in a constant state of vibratory motion, the particles of the hottest bodies moving with the greatest velocity, and through the greatest space; that in liquids and elastic fluids, besides the vibratory motion, which must be conceived greatest in the last, the particles have a motion round their own axes, with different velocities, the particles of elastic fluids moving with the greatest quickness; and that in ethereal substances, the particles move round their own axes, and separate from each other, penetrating in right lines through space. Temperature may be conceived to depend upon the velocities of the vibrations; increase of capacity on the motion being performed in greater space; and the diminution of temperature, during the conversion of solids into fluids or gases, may be explained on the idea of the loss of vibratory motion, in consequence of the revolution of particles round their axes, at the moment when the body becomes liquid or aeriform; or from the loss of rapidity of vibration, in consequence of the motion of the particles through greater space.

"If a specific fluid of heat be admitted it must be supposed liable to most of the affections which the particles of common matter are assumed to possess, to account for the phenomena; such as losing its motion when combining with bodies, producing motion when transmitted from one body to another, and gaining projectile motion when passing into free space; so that many hypotheses must be adopted to account for its agency, which renders this view of the subject less simple than the other. Very delicate experiments have been made, which shew that bodies, when heated, do not increase in weight. This, as far as it goes, is an evidence against a subtile elastic fluid, producing the calorific expansion; but it cannot be considered as decisive, on account of the imperfection of our instruments. A cubical inch of inflammable air requires a good balance to ascertain that it has any sensible weight, and a substance bearing the same relation to this, that this bears to platinum, could not perhaps be weighed by any method in our possession."

Heat and light are so intimately combined, and so generally found united in one and the same phenomenon, that we frequently associate them together with our ideas. It is easy, however, to conceive heat as separate from light. Thus water in a tea-pot occasions the sensation of heat, but no light is emitted. If I withdraw the poker from the fire, the one end may be red hot, and there light and heat

are combined; but the other end which I hold in my hand communicates the sensation of heat, but without any light a companying it.

It is however, extremely probable that the s bstance which occasions the sensation of heat, and that which occasions the sensation of light are but one and the same, as they have so many properties in common, and are governed by the same laws.

Light is communicated from a luminous body in all directions, and so also is heat.

Fill a tea pot with hot water and hold it out in one hand, we may place the other hand above the tea pot at a little distance, or on either side of it, or below it, and in all these situations a sensation of heat will be experienced. Now this sensation must be caused by the particles of heat reaching the hand, and not by the particles of air, for when the hand was held in a horizontal direction, or below the tea-pot, the air in contact with it, on being heated, would ascend upwards from its becoming lighter. Heat may also be communicated through a vacuum, though not so readily as through the air. The same experiments may be ascertained by holding out a hot poker.

It is well known that if a candle be held before a concave mirror, its rays will be concentrated to a point called the focus. Now particles of caloric will be reflected and concentrated in exactly the same manner. That the heat of a common fire will be reflected is familiar to every one, and is seen in the reflectors of tinned iron, to increase the effect of the fire in roasting meat, or for other culinary purposes. But dark caloric, as the heat proceeding from a vessel filled with hot water, may also be reflected in the same manner as light, and by means of a concave mirror may be concentrated to a focus, which focus is precisely at the same point to which the ray from a luminous body would be concentrated. This shews us that the calorific emanation of the particles of heat, make the angle of reflection equal to the angle of incidence.

As there are certain surfaces which reflect light better than others, so also is the case with the reflection from heat, which is much better reflected from polished metallic mirrors, than from mirrors made of glass.

The best m thod of rendering the reflection of heat sensible, is to employ two metallic mirrors, and so placed that a warm body, for instance, a bo ly of boiling water, may be in the focus of one of the mirrors, and that the calorific particle transmitted to this mirror may be reflected to the other mirror, and if a thermometer be placed in its focus it will be sensibly affected by the heat, and will rise; if part of the surface of the mirrors be covered with cloth so that there may be less reflection from it, the thermometer will not rise so much, and the difference will be exactly in proportion to the quantity of the surface of the mirror which is thus covered. Thus, if one half of one of the mirrors be covered, heat will be reflected only from the other half, and the thermometer will rise only half as much as if there were no part covered, if three-fourths be covered the heat will be reflected from only the fourth part left uncovered, and the thermometer will rise only one fourth as much.

In the same manner as the rays of light are dispersed by a convex mirror, so also are the rays of heat.

It is a very remarkable fact, that if a piece of ice be placed at the focus of one of the two mirrors, instead of the bottle of hot water, as in the last experiments, and a thermometer in the like manner be placed at the focus of the other mirror, the thermometer will be affected, and will sink in the same manner as it rose before. Also if part of one of the mirrors be covered with cloth, such as would prevent its reflecting heat in the last experiment, the thermometer will not be depressed so much, and only in proportion to the part of the surface left uncovered. This remarkable phenomenon of what appears to be a reflection to a focus of cold particles was observed as early as the sixteenth century, for it is noticed in "*Magia Naturalis*," pub-

lished in 1590, by Porta, a nobleman of Naples.

From this experiment some have been inclined to suppose that there were frigorific particles, in the same manner as it is supposed that there are calorific particles; but the above phenomenon may be explained without any such supposition, and there are a variety of facts to prove its incorrectness, and to shew that no substance in nature with which we are acquainted is absolutely cold, but only relatively so, that is, when placed near a body which has more heat than itself, but that the same body which in one case will be called cold, will, when brought near a body possessing less, be comparatively warm, and will increase its temperature. For example, a piece of melting ice will be justly said to be cold, as being colder than our hands, or perhaps the surrounding air. But let us suppose that in the time of very hard frost, the thermometer in a chamber indicates a temperature of 25° of Fahrenheit, if a piece of melting ice, of which the temperature is always 32° exactly, be brought into this chamber near the thermometer, the ice being warmer than the air will give out heat, and the thermometer will rise.

If a piece of iron be held a very short while in the fire, it will immediately become hot, and if withdrawn it will then disperse or radiate heat all round it, but that heat although sensible to the touch will not be visible to the eye. If the iron be kept a little longer in the fire it will become hotter, will on being withdrawn radiate more heat, but still invisible. If the iron be kept a considerable while in the fire it will itself acquire a red colour, and when withdrawn it will disperse a greater degree of heat than before, and will enable us to see, and if we consider heat and light as modifications of the same substance, we may say that the heat is now luminous. If the iron be made still hotter than this, it will when withdrawn give out more light and heat.

If a piece of hot iron be put in a dark place we observe that it gives out more heat at first, and gradually less and less, and that as it diminishes in the heat it gives out, it also in the same proportion becomes less and less visible, until at last it gives out heat only, and it has become invisible to our eyes.

In these experiments are we to say that the iron gives out two kinds of rays, calorific and luminous, and that the luminous rays are not emitted but when the iron is beyond a certain degree of temperature, and that gradually a greater and greater quantity is emitted as the temperature is increased; or is it more natural to suppose that the rays which occasion heat and vision are the same, and that the reason why we see from the rays when the iron is very hot, and do not see at other times, depends on the construction of our eyes. May we not suppose that there are animals whose eyes would receive light as well as heat, from the iron, whilst it excited no sensation in us but heat only.

Some light may be thrown upon this subject from the experiments of De Laroche, on the passage of caloric through glass. He found that when a piece of glass is held near a body which is of a very low temperature, that very little heat was transmitted through it; but if a body of a higher temperature be employed, that much more heat is transmitted through the glass than the difference of temperature would lead us to expect; and that if a body of a higher temperature still be used, the quantity of heat transmitted still increases with an augmented progression, and so on continually, until a body of such a degree of heat as to be luminous be employed, and even then the heat transmitted increases in its proportion as the light becomes more vivid. Thus, if a body at 600° transmit as much heat through glass as to raise the thermometer a certain number of degrees above what it was raised to, by the transmitted heat of a body at 400°, the transmitted heat of a body at 800° will raise the thermometer more than double that number of degrees and the transmitted heat of a body at 1000° will raise the thermometer much more than the difference be-

tween the heights to which it was raised by the body 800° above that by the body at 600°.

May there not then be an analogy between our eyes and the glass employed in these experiments. The glass is little pervious to heat from a body at a low temperature, but goes on becoming progressively more and more pervious to the heat at a high temperature, so that when the body is at a very high temperature, so as to be luminous, there is very little of the heat which proceeds from it to the glass which is not allowed to pass through it, and so in like manner the radiating heat, proceeding from a body of a low temperature, may not be so refracted by our eyes as to form on the retina an image to excite in the optic nerve a sensation of sight, but it may be so refracted when it comes from a body of high temperature giving out abundance of heat. If this be the case, then light and heat are the same substance, light being radiating heat coming from a source sufficiently warm to become sensible to our eyes.

There are evidently great difficulties attending this subject, which it may be hoped the further investigation of philosophers will remove. As we find bodies giving out low degrees of heat without giving any light, so also there are bodies which give out a considerable share of light without heat. Thus the moon's rays have never, by any means yet employed, been made to indicate the smallest degree of heat.

All we can say with certainty is, that wherever there is much heat, there is light also; and where there is much light, there is also heat; that the two are thus blended together, possess many similar properties, and that there are many probabilities to lead us to suppose that they are only different modifications of the same substance.

Of the propagation of heat.—Heat is communicated from one body to another with a rapidity in proportion to the difference of temperature between them. Pour boiling water into a basin, and plunge a thermometer into the basin, and leave it there, and observe how many degrees it sinks the first five minutes, and how many the second five minutes, and so on. It will be seen that the temperature diminishes very rapidly at first; or, in other words, heat is given out very rapidly from the water to the surrounding bodies, and the thermometer sinks a smaller number of degrees the second five minutes, and a smaller number of degrees still the third five minutes, and, in short, that less and less heat is given out in proportion as the temperature of the water approaches that of the room. It is not so easy to measure the degrees of heat given out by iron as it cools, but if the student holds his hand near hot iron, from time to time, he will be satisfied that it gives out most at first, and less and less rapidly as it approaches the temperature of the surrounding bodies; following in this respect the same law as water.

Newton was the first who made this observation respecting the communication of heat from one body to another. It was his opinion, that when two bodies were in contact they must every instant mutually communicate quantities of heat in exact proportion to what each of them possessed. This opinion he established by a number of experiments on bodies where the difference of temperature of two of them did not exceed 212°, or that of boiling water, and in such cases the rule is correct, or rather the error is so small as not to be perceived. Later experiments, on bodies which had a much greater difference of temperature than 212°, have incontestably shewn, that Newton's rule was only an approximation to truth, and that when a body is made much warmer than 212° above the air, or any neighbouring body, it gives out a degree of heat to the air, or to such body in contact with it, much beyond the simple proportion stated. Thus, if a body gives out a certain degree of heat at 200°, if it be raised to 300° it will give out so much more, but if it be raised to 400° the difference between what it now gives out, and what it gave

out at 300°, will be much greater than the difference between what was given out at 300°, and that given out at 200°: again, if the body be raised to 500°, the increase of what it gives out will be greater still.

When heat is communicated from one solid body to another, it is first conveyed to the nearest particles, and from them to those beyond them, and from these again to those more distant, and so on. Thus, if the end of a poker be put into the fire it is made red hot, and the heat is transmitted from one part of the poker to the other till it arrives at the farther end. As the poker which is warmed in this way is all the while giving out heat to the surrounding air, the end remote from the fire can never arrive at the heat of that which is in the fire, but it will become very warm if allowed time. In fluids when particles are heated they expand, and rising upwards they give out part of their heat, as they pass, to the particles with which they come in contact, and this is usually the way by which fluids are heated.

In fluids heat may be communicated downwards, from a part which is warmed to that immediately next it, and so on, but this process is exceedingly slow. As heat expands all bodies the heated fluids swims at the top, and the progress downwards goes on so slowly, that whilst that on the surface is extremely warm that below may be very cold. Fill a wide mouthed bottle with water, and put a red hot poker into the neck of it, whilst the water there is made boiling hot, the temperature below is scarcely affected. Hence the surface of a pool is often felt warm in summer whilst the deeper water is felt cold on walking into it; whilst the surface of the ocean in the torrid zone is raised to a warm temperature by the sun, the thermometer let lower down will ascertain that the heat is far less at a great depth.

When heat is communicated to a fluid from below, as in the case of water in a kettle on the fire, the particles which are heated becoming of less specific gravity than those above them, are forced up to the surface, and in their progress give out part of their heat to the fluid, and on arriving at the top they float there; and other portion of the fluid now receiving the heat also rises upwards, and thus the whole fluid in the vessel becomes of an equal heat.

When the weather becomes cold, the water floating on the surface is at first warmer than the incumbent air, and it therefore gives out part of its heat to the stratum of air in contact with it, and as it thereby on losing part of its heat becomes denser than the water below it, it sinks to the bottom, and a fresh body of water comes in contact with the air at the surface. This surface imparting heat to the air tends to moderate for some time the severity of the cold, as different quantities of the water successively give out of their heat to the air, the whole body of water in a pond or lake will necessarily at last arrive at the same temperatute. The operation goes on until the temperature be lowered to about 42° of Fahrenheit's thermometer, after which, the abstraction of heat from water no longer causes it to contract into smaller space, but on the contrary it expands in a small degree, and therefore, being lighter than the water below it, will continue to float on the surface, and no more heat will be abstracted from the water but by the slow process of its coming from particle to particle in the same manner as in a solid. Hence, when ice is formed at the surface, the water below may be much warmer.

When water is very deep, it is evident that the process of cooling in succession the different strata that come in contact at the surface, until the whole body of water in the lake or pond be brought to a low temperature, must occupy a very considerable time, and the longer in proportion to the depth. Hence it happens that when all the shallow pools are frozen over, deep lakes like Loch Ness, in Scotland, may continue unfrozen.

As heat is communicated from one body to another, there is a tendency to an equilibrium of heat in

all bodies in the same vicinity. If I lay hold of a piece of wood, or of a poker, which is colder than my hand, after some time the wood, or poker, is brought to an equal warmth with my hand. If on the other hand I lay hold of a poker warmer than my hand, heat is communicated, and my hand is warmed. If a certain quantity of water at 80° of temperature be mixed with an equal quantity at 160° of temperature, the mixture will be found by the thermometer at 120°, which shews that 40°, had been abstracted from the warm water to raise the other water 40°, or to 120°. A piece of iron put in the fire, or water in a kettle placed on the fire, receive heat from it. Bring a jug of water into a warm room from a cold spring or cistern, and let it remain some time in the room, then plunge the thermometer into it, and it will be found to be of the same temperature with other bodies in the room. On the other hand, dishes placed on the table give out their heat, and come down to the temperature of the room.

Water, milk, spirits, or wine which have been long in a room, will be found by the thermometer to be of the same degree of heat.

All bodies do not conduct heat with equal readiness.—If I put a poker in the fire the end of it will become red hot, and heat will be gradually communicated along the poker, and the hand may from time to time ascertain the progress, until at last the end by which we lay hold, is felt to be quite warm. A piece of glass for instance, a long glass tube may be put in the fire, and one end may be made excessively hot, and yet no great degree of heat felt at the other. Heat is indeed communicated from one part to another, but very slowly. If I put a piece of wood in the fire whilst one end is consumed, the other will not have received much heat.

There is, however, in all bodies a tendency toward becoming of an equal degree of heat, and in the same apartment, if there be no fire to make one part warmer than another, the chairs, tables, marble slab, fire irons, books, &c. will all be of an equal temperature, as may be ascertained by the thermometer.

It will seem at first to contradict this assertion, that the hand, applied to a piece of cloth in the room, will experience no cold, but if applied to a table will feel cold, and still greater cold if applied to a marble slab, and more still if applied to an iron stove or fire irons. This contradiction is, however, only in appearance. As the hand is warmer than the cloth, heat will be conveyed from the hand to raise it to the same temperature, but as cloth conducts heat very slowly, and the cloth has but little capacity for heat, very little is wanted to raise the parts in contact with the hand to the same heat. More heat will be required to raise to the same temperature the wood of the table in contact with the hand; and as the marble is thrice as solid, that is, contains thrice as much in the same space, and has a greater capacity for heat, a greater degree of heat would be abstracted from the hand, to raise the parts in contact with the hand to the same temperature; and for a similar reason, a still larger portion of heat will be abstracted from the hand by iron, and accordingly a stronger sensation of cold is experienced. If I take a ball of iron in my hand, it at last becomes of an equal warmth with my hand, and so does a ball of marble, or of wood, and no sensation either of heat or cold is felt in handling them afterwards.

From iron conducting heat very fast, and from its great specific gravity, a piece of iron out of doors, in time of cold weather, if touched by the hand, must carry off from it much heat, and occasion a sensation of intense cold. In severe weather in Canada, or Russia, it is said, that handling a bar of cold iron, will injure the naked hand, almost as much as if it were put in hot water. If the thermometer be at —40° it is 138° below 98°, the heat of the hand, which is a greater number of degrees than 114°, which the heat of boiling water is above that of the hand.

The same causes which make iron carry off more heat than a less

solid,[1] and more porous body, will also cause iron to communicate heat to the hand more rapidly than wood or cloth of an equal temperature.

The quantum of heat given out in a moment, and the sensation of heat experienced, depend therefore, on the power bodies have of conducting heat, and it is a general rule, that bodies which rapidly receive heat, as rapidly give it out, and bodies in which the temperature rises slowly, as slowly give out their heat.—Of this spermaceti oil is an example, into which, although it has been raised to a great heat, as indicated by the thermometer, the hands may be plunged and held for a short while, and no pain experienced, which is a circumstance which has astonished most experienced chemists. Water thrown on this oil would be quickly raised in the form of vapour.

The bodies which most slowly transmit heat are those which are composed of very fine filaments, as hair, wool, silk, downs, bran, straw, &c. As these substances are small and separated from each other, the heat in being propagated through them, has to make many windings and turnings, and they also enclose within their hollow spaces a great quantity of air, which very slowly conducts heat; we see innumerable instances every day of the non-conducting power of these bodies. Animals are furnished by nature with their proper clothing of their hair or wool. Our clothes are an artificial covering, which answer the same purpose, and in like manner prevent the heat of the body from being carried off into the surrounding medium. This is the manner in which clothing keeps us warm, not by communicating any heat, but by preventing the escape of the animal heat produced within us, by the process of breathing, and the circulation of the blood. If a piece of cold iron were wrapped in wool, it would not become any warmer; nor would any heat be produced by any clothing which might be put on a lifeless body.

If a piece of ice were wrapped up in wool or blankets, it would not melt, except very slowly. These bodies prevent the rapid transmission of heat; and as, therefore, they do not allow heat to pass through them, but very slowly, there can be no reason why the ice should melt.

We often see straw or litter spread on the pavement in hard frosty weather, and as these bodies do not readily transmit heat, they prevent the heat being carried off from the pipes which conduct the water, and preserve them from being burst by the water freezing within them.

For the same reason, bran or sawdust spread upon a stone floor, will answer the purpose of carpeting, and prevent the heat from being carried off from our feet.

From the weak conducting power of air, we may account for the advantage of double windows, in Russia, which, by confining the heat within their houses, keep them warm. The same contrivance preventing the introduction of the external heat, is found useful in the West Indies. Two walls, with air between them, are useful in not admitting the heat into ice houses. In cold climates an inner covering of boards, a few inches from the walls of a house, so as to enclose an intervening body of air, greatly adds to the warmth and comfort.

Sand is, like bran, a very slow conductor of heat. The red hot balls employed by the garrison of Gibraltar, to destroy the Spanish floating batteries, were carried from the furnaces to the bastions in wooden barrows, with only a layer of sand interposed, and this was found sufficient to prevent the balls, though in a high state of incalescence from setting fire to the wood. After the gunpowder and wadding is put into the gun, a small bag of sand is next inserted, and is sufficient to keep the heat of the red hot ball from making the gun go off.

Snow on the ground, being a weak conductor of heat, prevents it from being carried off by the cold incumbent air in the time of hard frost, and thus preserves the tender plants from injury. Straw spread upon beds in a garden will have the same good effect.

Potatoes and other vegetables are

often stored up in pits in winter. These pits are usually covered with straw and light earth, which do not draw off the heat, and are said, in common language, to prevent the frost entering. A wet clayey covering, put over the straw, would have a much greater conducting power, than loose dry earth, and therefore, though apparently the most secure, would in reality be the worst preservative. When the wet penetrates as far as the potatoes, from the great conducting power of water, injury must be done. Well dried peat, from its lightness, and little disposition to retain moisture, forms an excellent covering.

If after very severe long continued frost, different kinds of ground be dug up with a spade, to ascertain how far the effect of the frost has penetrated, it will be found that it has penetrated least of all into grass land; a little deeper into the loose earth of the beds of a garden; and far deeper, perhaps twice, or thrice as far, into a stiff clayey soil.

We see every day, an instance of the difference of power in conducting heat in the wooden handles of tea pots, which may easily be held by the hand, whilst the tea pot itself is too hot to be touched.

Heat is communicated from different bodies to the surrounding air, or to other bodies near them, in very different degrees, according to the nature of their surfaces.— If two glass bottles, of equal size and thickness of glass, and of the same shape, be filled with warm water, and one of the bottles be covered with an envelope of fine muslin, that bottle will give out heat to the surrounding air with much greater rapidity than the other bottle; so that, after any given time, if the temperature of the water in the two bottles be ascertained, it will be found that the water in the glass bottle which had no envelope, is much warmer than the other. If two such bottles be filled with cold water, and both be brought into a warm room, near the fire, the bottle which has the envelope of muslin will be warmed much more rapidly than the other. It is thereby found, that the same kind of surface which more rapidly gives out heat, also more rapidly receives it. For this discovery, which may be of much practical utility, the world is indebted to Professor Leslie and Count Rumford.

Mr. Leslie got a vessel of thin polished metal, having four rectangular sides of exactly equal size, one of these was covered with thin writing paper, the second with a piece of polished glass, the third with the smoke of a lamp, and the fourth was left with its own bright polish. This vessel he filled with warm water, and after a little while he placed a differential thermometer opposite to each of the four surfaces, the heat radiating from them, heated the air in the bulb, which of course dilated, and repelled the liquid in the thermometer, but to very different degrees, according to the nature of the surface. The liquid was repelled most of all by the surface covered with the smoke of the lamp, rather less by the surface covered with paper or glass, and least of all by the naked polished surface.

It results, therefore, from this and similar experiments, that for such vessels as urns or tea-pots, in which it is wished to keep water as warm as possible, a naked polished surface is that which is the most proper.

The following table of the radiating powers of different substances is given by Mr. Leslie:—

Black from smoke . .	100
Water	100
Writing paper . . .	98
Crown glass	90
China ink	88
Ice	85
Mercury	20
Bright lead	19
Polished iron	15
Tin, silver, copper, or gold	12

The same philosopher also performed a variety of experiments, in order to ascertain the reflecting power of different surfaces on which heat might fall. The result is shewn in the following table:—

Yellow copper . .	100
Silver	90
Tinfoil	80
Steel	70
Lead	60
Tin covered with mercury . . .	10
Glass	10
Oiled-glass . . .	5

If the bulb of a thermometer be covered with thin gold leaf, and exposed to the rays of heat, or to the solar rays, the mercury will rise, but not very far. If the bulb be covered with the smoke of a candle or of a lamp, or with a thin coating of lamp-black, and exposed in a similar manner to the rays of the sun, or to the rays of heat, the mercury in the thermometer will rise eight times as far. The blacking having but a very small reflecting power absorbs the rays which fall upon it.

Upon the principle of the absorption of the light by blackened surfaces, Mr. Leslie contrived an instrument to measure the degrees of light, which he called a photometer. It is a very delicate differential thermometer enclosed in a thin pellucid glass tube. One of the bulbs is of black glass, which absorbs the light. When the instrument is brought from a dark place into the light, the light being absorbed, that bulb becomes warmer, and expands the air contained in it, consequently the liquid enclosed is repelled to a distance, and this distance will be greater or less, precisely in proportion to the quantity of light. In a clear day it will be much greater than in a dark day.

Effects of Heat.—*An increase of temperature produces an expansion in almost all bodies, and if sufficiently great, it changes solid bodies to a state of fluidity, fluid bodies to an aeriform state, and has various other effects.*—An increase of temperature produces expansion, or overcomes in a certain degree the cohesive force with which particles of bodies adhere together, and makes them remove further off. A piece of iron, for instance a poker, which might have just passed through a ring when cold, will not pass through when heated. Boil water in a glass tube at a candle, and the water will evidently appear to occupy more space. Put your warm hand to the bulb of a thermometer, and the expansion will cause the mercury to rise in the tube.

Different substances suffer different degrees of expansion from the same increase of heat.—The following table will shew the expansion of several metals on being raised from 32°, the temperature of melting ice, to 212°, that of boiling water:—

	At 32°	At 212°
Platinum . .	100000	100086
Steel . . .	100000	100122
Iron . . .	100000	100126
Copper . .	100000	100170
Brass . . .	100000	100192
Tin	100000	100248
Lead . . .	100000	100287
Zinc . . .	100000	100300
Mercury . .	100000	101835

From the above table it will be seen that mercury expands more than any of the other metals, or about a fifty-fourth part. The metal is also very sensible to the smallest accession of heat, and hence it is peculiarly adapted for being employed in the thermometer as a measure of heat. The mercurial thermometer has, therefore, received a decided preference over thermometers in which oil, water, or spirits of wine was enclosed in the tube. It has other advantages for this purpose, for it will not freeze without a degree of cold unknown in our climate, and will not boil below a heat of 600°.

Water, like other bodies, expands with heat. It is at its greatest density at about 42° of Fahrenheit, and 100000 of parts at that temperature raised to boiling point or 212°, will occupy the space of 104577 parts, increasing about a twenty second part of its bulk. Linseed oil is expanded by heat to a greater degree than water:—thus 10000 parts of linseed oil at 32°, if raised to 100°, will occupy the space of 10276 parts, and if raised to 212°, will occupy the space of 10725 parts. Alcohol or spirit of wine is more expansible than either mercury, water, or linseed oil, for

10,000 parts at 32° will expand to the bulk of 10,416 such parts, if raised to 100°.

An addition of any given number of degrees of heat to a liquid at a low temperature will produce a certain expansion; but an addition of the same number of degrees to the same liquid, at a higher temperature, will produce a still greater relative expansion. In general the nearer a liquid approaches its boiling point, the greater is its expansibility. Thus, 10,000 parts of water at 50° raised to 120°, occupy the bulk of 10,138 such parts; but 10,000 of water at 120° raised to 190°, occupy the bulk of 10,359 such parts.

Air, gases, steam, and all vapours are subject to the same laws of expansion from heat, and they are affected by it to a much greater degree. The following table will shew the increase of bulk of 100000 parts of air, gases at different temperatures, from 32° to 212°.

32° . . .	100000
40° . . .	101666
50° . . .	103749
60° . . .	105824
70° . . .	107904
80° . . .	109984
90° . . .	112064
100° . . .	114144
110° . . .	116224
120° . . .	118304
130° . . .	120384
140° . . .	122464
150° . . .	124544
160° . . .	126624
170° . . .	128704
180° . . .	130784
190° . . .	132864
200° . . .	134944
212° . . .	137440

The increase of the elastic force of heat is very different between dry gases and watery vapour, after a place is furnished with as much as it can contain. The elastic forces of the dry gases at the temperature of boiling water, and at that of melting ice are in proportion to each other as 1⅜ to 1; those of watery vapour at the temperature of boiling water to that at melting ice, in a saturated space, as 150 to 1. If steam, therefore, be confined it will exert great force; and by being so confined that the temperature rises above 212°, its force will still further increase. Hence its great power when applied to produce motion in machinery in the steam engine.

Expansion by heat, and contraction by cold, are almost universal effects, but there are a few apparent exceptions.—The most remarkable is water, which is contracted by cold, until its temperature sinks to about 42°; after which the increase of cold, or to speak in strict language, the abstraction of heat, instead of diminishing the bulk of water, increases it. This increase is greatest of all when the water passes from the fluid into the solid state. For 1000 parts of fluid water at 32°, when frozen, will occupy the space of 1097 such parts which is an increase of nearly one-tenth. We hence see, that the specific gravity of ice is much less than that of water, being only about 920, and the reason why ice floats on the surface of water, and also why a large body of ice will swim, and support animals and men upon it.

This increase of the bulk of water when converted into ice, depends upon a certain arrangement of particles called crystallization, of which it is here necessary to give some account.

If any kind of salt be dissolved in water in such quantity that the water is saturated, and that water be boiled a little on the fire, until part be evaporated, and if it be then allowed to stand, and become cold, saline crystals will be formed exactly similar in shape with those which were dissolved in it, according to the nature of the salt. Now it is supposed, that in like manner when simple water itself passes from a liquid to a solid state, that is to say, when it freezes, the different particles arrange themselves in a particular manner, and thereby occupy more room. Indeed we see, from the manner in which the moisture freezes on the glass of the windows, that it is the nature of water thus to arrange itself when freezing.

We may see the same, also, by putting water in a wine glass, in

the time of hard frost, and letting it remain a short while exposed to the cold; and still better, if we then pour out the water which remains unfrozen. A different arrangement will be produced, if some common salt be first melted in the water; and a still different, if any other salt, as the sulphate of iron, be employed.

When, therefore, ice is formed, and occupies more room than the water from which it was produced, it arises from the mechanical disturbance of the particles, and the hollow or vacant spaces which they form, and not from any change of the natural bulk of the particles themselves. It is supposed, also, that water begins thus to arrange itself after it arrives at 42°, and the arrangement goes on, and is completed when it freezes at 32°, or below that point. For, although the degree of melting ice be uniformly 32°, that of freezing water may be as low as 22°, if in a close vessel, from which the air is excluded, although when congelation takes place the temperature returns to 32°. In the open air water may be below 32° before freezing, if it be not agitated. We may prove this by exposing water to frost for some time, in a wine glass, and then shaking it. When ice is exposed to a still greater degree of cold it will expand still more, which arises from the crystallization, or arrangement of its particles, becoming more complete.

There are many other liquids in which there is an expansion in passing from the liquid to the solid state.

When water, in which any salt has been dissolved, is frozen, there must be an expansion, from the water itself expanding independent of the salt.

Iron is greatly expanded by heat, and contracts as it cools. This will hold true, provided the metal has not been so far heated as to be actually melted; for it is observed, that when melted iron, or as it is called, cast iron, cools, and becomes solid, it increases in bulk, and has consequently less specific gravity. This is proved by throwing a piece of cast iron into a vessel full of the melted iron, when it swims at the surface, in the same manner as a half-penny would swim on mercury, or a bit of wood in water. This phenomenon is also referred to crystallization, or arrangement of the particles of the iron.

Antimony and bismuth when they cool after being melted, expand in a similar manner. Other metals contract. Why they should not crystallize and expand like iron we cannot tell, and merely know the fact that they do not do so.

As heat in general makes the particles of bodies expand, or remove further from each other; so in like manner, if the heat be increased to a sufficient degree, the cohesion will be so far destroyed, that they may be easily moved amongst themselves, or in other words, become fluid.

Fluidity is therefore an effect of heat.—Water, which in cold weather becomes solid, is melted by a certain increase of heat. Mercury which may be frozen by extreme cold, is kept by heat in a fluid state, at all times in our climate.

We see then, that a certain very small portion of heat is requisite to give fluidity to mercury, a still greater to water. Substances also which are usually solid, melt when a sufficient degree of heat is applied, and this degree of heat is always the same to the same substance. Thus, ice uniformly melts or becomes fluid at 32°, sulphur at 225°, lead at 600°, and tin at 440°. In fact, the most solid substances in nature, if sufficient heat were applied, would be rendered fluid. Thus, iron is every day melted in our iron founderies, and so also are other metals. The various kinds of earth, and other substances in the bowels of our globe, are liquefied by the vast heat in those magnificent furnaces of nature the volcanoes, and issuing out at holes in the sides of the conical hill, formed by volcanic action, run down in streams of melted lava, cutting their way through former lava, and every opposing obstacle, they hold on like a river in its bed, and sometimes for many miles till they reach the sea. The same lava, when many weeks and months have al

lowed it time to give out its heat to the surrounding soil and air, becomes solid like a rock. It becomes, in fact, a rock from which houses are built, and with the blocks of which streets are paved. This is the case with Naples, Rome, Florence, Leghorn, and other Italian towns.

Many bodies usually solid are melted by a very small addition of heat. If eight parts of bismuth, five of lead, and three of tin, be melted together, and the whole be allowed to cool, the mixture thus produced will be so fusible that, if it be put into boiling water, it will melt. Tea spoons are made of this composition, and are sold at the shops to be used in making this experiment, and to astonish those who are ignorant of such effects being produced. If two parts of lead, three of tin, and five of bismuth, be melted together, and if then one part of mercury be poured into the mixture, when in a state of fusion, and the whole be stirred together, and then the compound be allowed to cool, it will melt afterwards with less heat than that of boiling water. If equal parts of lead, tin, and bismuth, be melted together, the composition may be kept in fusion when boiled over the flame of a candle.

As a certain portion of heat will render different bodies fluid, so also if a still higher degree of heat be communicated they may be changed into an aeriform state.—Thus water rises into vapour, and if heated as high as 212° this operation goes on rapidly, and the whole is dissipated. If a little mercury be heated in a crucible, or iron spoon, on the fire, it rises in fumes and is dissipated. Fumes also rise from melted lead, and although if kept heated it absorbs more oxygen than it gives out of its own substance, and, therefore, increases in weight, when converted in this way into red lead, yet if it still continue exposed to great heat, its substance is gradually dissipated in the air. In fact all melted metals give out fumes, and only require a sufficient heat to have their whole substance volatilized. Wood, charcoal, or common mineral coals, when burnt in a common fire, absorb oxygen, and are in a large portion converted into carbonic acid gas, and rise also in a simple volatile state, uncombined with oxygen, into the atmosphere along with smoke. Earths in like manner lose of their substance by a sufficient degree of heat. In fact it is an universal rule in nature, but as it requires a very great heat to render some bodies fluid beyond what is necessary for others, so it requires an infinitely greater to volatilize them.

A certain degree of heat is necessary for carrying on of various processes in the animal and vegetable economy, as fermentation, putrefaction, and decomposition.—If this degree of heat be abstracted from them these operations cannot take place. In Russia, when the winter sets in, it is the custom to kill their poultry intended for use during that season, and pack them in tubs with layers of snow between. Beef, veal, mutton, and other kinds of animal food, are preserved also by the frost, and after several months, if carefully thawed in cold water, retain all the freshness and agreeable flavour, as if but a short time killed. In this country a similar method is adopted with salmon, which are packed in boxes with ice, and are thus brought from the remotest parts of the empire in a fresh state to the London market. The effect of the cold in these cases seems to be that it reduces to a solid state the different juices of the animal substances, and thereby prevents that internal motion and mixture, which goes on when they putrify and are decomposed. In fact there seems to be no limit to the length of time which they may be preserved with their constitutions unaltered, provided the cold be continued. Mr. Pallas gives an account of a rhinoceros found on the banks of a river that falls into the Lena below Yakutsk. The carcase was at first almost entire, and was covered with the hide, some of the muscles and tendons were actually adhering to the head when Mr. Pallas received it. The preservation of this animal was caused by its being buried in earth, in a per-

petual state of congelation. A more remarkable instance occurred in 1799, when an animal of uncommon size was found embedded in a mass of ice, near the shores of the Frozen Ocean. The bones of this animal bear no resemblance to those of any known animal on earth, and it is therefore considered as antediluvian, and it must then have been preserved from the remote period of the Deluge in the ice which enveloped him.

Animal and vegetable substances may in like manner be preserved by such a degree of heat as will expel moisture, and bind their component parts together, so as to put a stop to internal motion.—Fish are preserved by being exposed to the air so as to evaporate their moisture; and bacon and beef are preserved in a similar manner. Stacks of hay and corn are preserved and kept for a long time if they have been well dried before they have been got in. If, however, the stalks have been moist when the stacks were built, fermentation will ensue, and much heat will be disengaged, and thus the whole will be slowly consumed by a smothered combustion, and reduced to a state like charcoal. If at this time air be admitted, flame will burst forth, and hay ricks have often been consumed in this way. The great heat is supposed to arise from the condensation of water, which during the process entirely disappears, in the same manner as heat is disengaged by the condensation of water in the process of slaking lime. In the cases which we have stated, the dryness is produced chiefly by exposure to the air, which carries off the vapour which arises, but the same effect is produced to a much more remarkable extent if bodies be raised to a sufficiently high temperature, and continue to be kept at it.

In the same manner as extreme cold, which hardens and solidifies the components of animal substances, will preserve them from decay, so also will a sufficient degree of heat, which acts exactly in the same way.

Of the capacity of bodies for heat.—If a red-hot coal be taken from the fire, and dropped into a basin of water, it will raise the temperature of the water a certain number of degrees. If a piece of stone, of the same size, be taken out from the same fire, after it has been in it so long that it is of the same heat; and if it be dropped into a basin, of equal size, and containing an equal quantity of water, it will raise the water to a higher temperature than was done by the coal, as may be seen by the thermometer.

If, instead of the coal or the piece of stone, a piece of iron of the same size taken from the same fire, and, therefore, of the same temperature be put into a similar basin of water, it will raise its temperature still more. From these three simple experiments, we see that a coal, a stone, and a piece of iron, of equal bulk and heat, yet give out very different quantities of heat to bodies which they approach, or into which they are put. The stone containing a greater proportion of communicable heat than the coal, is said to have a greater capacity for heat, and the iron in like manner has a greater capacity for heat than the stone.

If a piece of wood, and a piece of iron, have both been near a fire for such a length of time, that they are both at the same temperature, and if I lay hold of the wood, and then of the iron, my hand is warmed much more by the iron, than by the wood. As the iron has a greater capacity for heat than wood, it contains a larger quantity in a given space, and therefore has more to give out to the hand, and its conducting power enables it to give it out.

This experiment may be tried with more accuracy by dipping at the same time the end of a rod of wood, and the end of a rod of iron, into boiling water, and after keeping them some time, withdrawing them, and wiping them; the rod of iron, when the hand is applied to it, will feel much warmer than the wood. If a piece of metal, for instance a spoon, be put into water, which may not be so hot, but that the hand may be put into it, the piece of metal may never,

theless be made too hot to be held by the hand. In all these examples the property of conducting heat, as well as the capacity for heat, has a share in the effect produced. In fact the two properties seem to be united in the same bodies, and to have a dependence upon each other.

The method employed by Dr. Black, who has the merit of having led the way in this branch of science, was to mix different substances together, which were at a common temperature before being mixed, and then ascertain the temperature after the mixture.

If a pint of water at 100°, and another pint at 212°, be mixed together in a basin, the temperature after the mixture will be 156°, or the exact mean between 100° and 212°. In this case, the one pint gains 56° which the other loses. In conducting this experiment, it is necessary to raise the temperature of the basin to such a height that it may not affect the result; for if the basin were cold it would abstract a considerable portion of the heat of the water poured into it, and the temperature of the mixture would be below the mean of the two, or 156°. But if instead of two pints of water, there be mixed a pound of mercury at 100°, and a pound of water at 212°, the temperature of the mixture will be considerably higher than 156°. It therefore follows that the water has not lost near so many degrees as the mercury has gained; and, therefore, a small portion of caloric will raise the temperature of mercury higher than it would water; and, therefore mercury has less capacity for heat.

Another and perhaps better way of ascertaining the capacity of bodies for heat, is to raise them to the same temperature, and then to bring them in contact with ice at 32°, or the melting point, and to observe how much ice they melt before their temperature is brought down to 32°. A body which would melt a double quantity of ice, would have a double capacity for heat; and that which would melt a triple quantity of ice, would have a triple capacity. In order to ascertain the quantity of ice melted by different bodies, with as great exactness as possible, Messrs. Lavoisier and Laplace, invented an instrument called the calorimeter, or measurer of caloric. It requires, however, extreme delicacy and attention to manage it, and will often give a varying result.

It would be highly satisfactory to the author to lay before his readers a table of the capacities of different bodies for heat; but the experiments of chemists have not been sufficiently numerous on this subject to render it possible.

Of Latent Heat.—If in the time of very hard frost, a basin filled with snow be brought into a warm room, the temperature of the snow will gradually rise to 32°, and then when it has come to that height, the snow will begin to melt, but this will be done slowly, and it will be a considerable time before all the snow has been changed into water.

If the thermometer be plunged into the water produced by the melting snow, or into the snow itself, it will indicate 32°, and this temperature will continue unchanged until the whole be melted, after which it will gradually rise to that of the room.

If instead of snow, we try the experiment with ice pounded into small portions, it will be found also to rise to the temperature of 32°, but no further, and as it goes on melting, the water produced and the unmelted part of the ice, will still continue at 32°; but as soon as the whole is melted, the temperature will begin to rise, and it will gradually ascend to the heat of the room.

If snow or ice be put into a saucepan and placed on the fire, notwithstanding the constant accession of heat which is communicated to it from the fire, there is no rise whatever in the thermometer, or in the temperature of the snow or ice when felt by the hand, until the whole be melted, the whole of the heat being consumed in reducing the snow, or ice, to a liquid state.

It is evident, that in all these cases, the snow and ice were every instant receiving heat from the surrounding bodies, or from the fire, and particularly in the case where the saucepan is put on the fire; yet, nevertheless, there is no sensible difference of heat indicated by feeling it with the hand or with the thermometer. The whole of the heat communicated was required to render the solid substance fluid, it is dispersed amongst its particles to keep it in that state, and becomes what is called latent heat.

Dr. Black was the first who turned his attention to this subject, which he was induced to do from observing in the time of a thaw, which lasted for several days, that the snow and the water in a pool where there were still snow and ice unmelted, never rose above 32°, whilst the air and the water in a pool, free from ice and snow, indicated a much higher temperature. He was thus led to perceive that the heat which the snow and ice received from the air in the time of a thaw, was absorbed and employed in rendering them fluid.

If upon a quantity of snow or ice, some boiling water be poured, part of the snow will be melted, and the remaining snow or ice will be of a temperature of 32°, and so also will be the whole of the water. The heat in the boiling water is absorbed or rendered latent, being required to melt part of the snow or ice.

This phenomenon of the absorption of heat is not peculiar to melting snow and ice, the same also takes place with any other solid substances which cannot be raised to a temperature above their melting point, until the whole be liquefied.

The absorption of heat is no where more remarkable than in the melting of different kinds of salt. Upon this principle various freezing mixtures have been made, which have been employed, not only for the purposes of philosophical research, but for useful purposes in the common arts of life. In the composition of a freezing mixture, the ingredients should be reduced to a fine powder and mixed together and made to melt as soon as possible. The vessel in which the operation is performed should also be very thin, in order that it may not communicate much heat to the mixture and diminish the effect. The student may satisfy himself of the truth of the absorption of heat by a few simple experiments. Into a tumbler of very warm water, put some powdered muriate of ammonia (sal ammoniac) and the heat will be greatly diminished. Place two basins of warm water on the table at an equal temperature, and into one of them sprinkle common salt, and after a short while ascertain the temperature; that in which the salt has been put will be colder than the other. Salt is sometimes ordered by medical men to be put into water, which is to be poured or dashed on a weak limb; besides amusing the mind of the patient, it makes the water a little colder, and thereby adds to its effect in strengthening the part to which it is applied.

One of the simplest, and at the same time one of the most powerful freezing mixtures is made by mixing common salt and snow. If a mixture of salt and snow be put into a saucepan which is put on the fire, and then an iron cup filled with water be placed in the mixture, the water will be frozen into ice. An iron cup is recommended, because that metal is a good conductor of heat. The mixture as it melts abstracts heat from all bodies around it, and withdraws so much from the cup and water as to produce congelation. If snow and common salt be mixed in an iron cup, or in a common porter pot, of which the outside is wet, and the cup or pot be then placed on a board or stool beside the fire, it will freeze so hard as to adhere. In these experiments pounded ice will answer still better. Confectioners in the warmest weather in summer easily make a freezing mixture by means of pounded ice and salt, and that is, perhaps, the only mixture which can be easily made at so moderate

an expense as to be of use in common life. Other freezing mixtures are employed by philosophers for the gratification of curiosity, and for ascertaining by experiment the laws of nature.

In order to produce a very high degree of cold, it is necessary to use different mixtures, and to cool the ingredients which are to be used in the second mixture in a vessel placed in the first mixture, and then, when mixed, they will produce a still lower temperature. Then other ingredients which have been brought down to this second temperature are to be mixed together, and a lower temperature still may be produced, and the operation still may be continued.

We see, therefore, that in all cases when a body passes from a solid to a fluid state, it absorbs a quantity of heat which disappears or becomes latent. Now this heat will again be made to re-appear, or to become sensible when the liquid returns to a solid state. We observe the air always becomes warmer during a heavy fall of snow. The vapour on becoming solid gives out heat which causes the warmth. After milk has been churned and butter has begun to be formed, immediately there is great heat felt. We observe the same thing takes place when water becomes solid in the slacking of lime. But there is an experiment which will clearly shew that heat is given out by water in the act of freezing. If whilst the air is considerably colder than 32°, the freezing point, for instance, at 22°, we expose to it a quantity of water in a tall glass, with a thermometer in it and covered; the water gradually cools down to 22° without freezing. If the water be then shaken, part of it instantly freezes into a spongy mass, and the temperature of the whole rises to the freezing point, or 32°, so that the unfrozen part has acquired 10° degrees of heat in an instant. This heat must have come from that part of the water which freezed, and this experiment shews that water gives out heat in the act of freezing.

An experiment more easily performed, will shew the same thing. In the time of very hard frost, take some ice, which will be found by the thermometer to be considerably below 32°, into a bason of water at 32°, which is to be brought to that temperature by exposing it a short while to the open air, a part of the water will soon be congealed, and the temperature of the ice, which was below 32° will be raised to that point. The temperature of the ice is increased by the heat it receives from the water which is frozen.

If sulphate of soda (Glauber's salts) be dissolved in boiling water to saturation, and the liquor be boiled some time, and then poured into a phial until the phial be full, and a cork be put into the phial to exclude the air, it is very probable that no crystallization will take place. But if after an hour or two, when the liquor is quite cold, the phial be shaken, then part of the liquor will crystallize, and considerable heat will be felt.

When water is poured upon the dry pulverized plaster of paris for the purpose of forming models or cornices to rooms, the mixture soon becomes hard, and great heat is disengaged from the water entering into a solid state.

As heat is absorbed and becomes latent when a body passes from a solid to a liquid state, so also the same takes place when a body passes from a liquid to an aeriform state. Suppose a saucepan of water is put upon a steady fire, which gives out an uniform degree of heat, the water gradually becomes warmer, and after a certain number of minutes it arrives at 212°, or thereabouts, and then begins to boil. Let us say it has done so in twenty minutes. It is clear that during the next twenty minutes an equal heat will be given out to the water from the fire, and yet if the thermometer be put into the water, it will be found to be not in the least increased in temperature, nor will it ever be so if it continue on the fire till the whole is evaporated. When the water has begun to boil, a larger portion than before is every instant changed into vapour, and it

is this vapour which absorbs or carries off the heat which continues to be communicated to the water. The vapour itself has a temperature of 212°, the same as boiling water, the heat, therefore, which it carries off becomes latent or insensible to the thermometer.

If water were boiled in a glass vessel, in which a thermometer was enclosed, and which was shut up to prevent the vapour from escaping, the temperature of the water would be raised much above 212°, but the instant the top part was opened, a body of vapour would instantly issue out, and the temperature would instantly fall to 212°. The vapour which has been formed has carried off the superabundant heat in the water.

The quantity of heat absorbed by a quantity of water when it is converted into steam, Dr. Black calculated to be so much as would raise its temperature 810° above boiling point, or to about 1022° of Fahrenheit. He was not perfectly satisfied with the accuracy of the means he employed, and requested his friend and pupil Mr. Watt, to endeavour to ascertain this point. This gentleman, to whom the research was of the highest importance in the construction of his steam engines, applied himself with great care to this subject, and the result was, that the quantity of heat absorbed by water, when it is changed into vapour, would be sufficient to raise it to 950° of Fahrenheit, which does not differ much from the result obtained by Dr. Black. If water at the temperature of 62° be put upon a fire burning regularly and uniformly, in order to make it boil, it must be raised 150°, or to 212°, before it boil, and as the whole water will not be converted into steam until it has received as much heat as might have raised it to nearly 1,000°, that is to say, about five times 150°, or 750° more than 212°; it will require five times as much time to be all evaporated, as it did before it began to boil.

As water when it is converted from a fluid to a solid state, gives out the heat which kept it fluid, so also, when water passes from a state of vapour to a fluid state, it gives out the superabundant heat which was required to raise it in vapour.* This property of steam has been successfully applied to the purposes of conveying heat over a large building. It has also been employed for heating water, boiling vegetables, and for a variety of culinary purposes. Count Rumford has the honour of contriving the means by which this property of steam may be rendered most useful in common life. The property of steam is successfully employed in the London breweries.

If at any time the hand has been brought into the steam issuing from the tea kettle, great heat has been felt. Hold a piece of board over the steam of a tea kettle that it may form into a liquid on the board, and then feel the heat produced, it will much exceed the heat occasioned by pouring upon it as much boiling water as would make the board equally wet.

CALORIMETER is an instrument invented to measure the quantity of heat, that any substance contains, which it has absorbed, and is capable of disengaging. It is done by melting ice, which is always rendered fluid at the same temperature, namely, 32° of Fahrenheit, and all the heat which is afterwards communicated to it does not raise its temperature, but is merely employed in melting it, and a double or triple quantity of ice will be melted by a double or triple quantity of caloric, so that the portion of the invisible heat which is employed, may be ascertained, by weighing the water produced from the melting ice. This is the principle upon

* In order to calculate how long it would take to convert any given quantity of water into vapour, notice the degree at which it is when put upon the fire, and subtract this from 212°; then divide 810° by the remainder; the quotient multiplied by the time the water takes to boil will be the result required.

which Messrs. Lavoisier and Laplace invented their calorimeter.

It is composed of two similar metallic vessels, contained within each other, and kept separated by little rods of metal, which it would be an improvement to make of wood, or of glass. The interval between the two vessels is filled with ice broken into small pieces, and heaped up, so as to form a continued envelop. To introduce the ice, the cover is lifted up, and when the apparatus is filled, it is replaced. It is clear, that by taking care to renew constantly this ice in proportion as it is melted by the effect of the temperature of the atmosphere, supposed higher than 0°, the interior vessel and the space in its inside, will be kept constantly at zero. But to effect this renovation, the water which is formed by this progressive melting, must be carried off; such is the intention of a cock on the side, placed in the lower part of the space between the two vessels.

Now in the interior vessel, there is suspended another still smaller, formed by the simple interweaving of iron wire, and intended to contain the body which it is wished to cool. The interval between the second and third vessel, is equally filled with ice, piled up in very small pieces, which is also introduced into it by lifting up the lid, and the water which is produced, as it is melted, runs out by a cock in the lower part, into a vessel, where it is collected to be exactly weighed. This being settled, let us admit for a moment, that the external air has no access into the interior of the calorimeter. Then after a time, more or less considerable, the interior ice will arrive at the temperature of the exterior interval, that it is to say at 32°, and it will keep itself invariably at this degree, as long as the exterior covering of ice shall not be totally melted. But introduce into the innermost vesssel a body of which the temperature is raised above zero, this body will be gradually cooled, and in cooling, it will melt the surrounding ice, which will produce a certain quantity of water, which will run out by the lower cock.

If this water be collected and weighed, it will be evidently the measure of the quantity of heat disengaged by the body on cooling down to 32°.

The experiment to be properly conducted, requires some precautions; first, care must be taken not to employ ice colder than 32°, for all the heat disengaged by the interior body, will be employed in bringing it to this temperature before melting it, and the effect will thus be incorrectly ascertained. This inconvenience is avoided by employing melting ice, or ice ready to melt, and performing the experiment in an atmosphere raised two or three degrees above zero, rather than below it. Then there will be a certainty that the temperature of the ice, with which the experiment is performed, is really at 32°, as it is wished, since it keeps at this fixed degree as long as it is not entirely melted. This has also another advantage. The introduction of external air into the calorimeter can never be totally avoided; if it were much warmer than the internal ice, it would melt a quantity which might be sensible, and which by mixing with the quantities of water resulting from the experiments would alter them; if on the contrary it were colder than 32°, it would cool the temperature of the ice, and prevent its melting. On account of the small density of the air, two or three degrees, or more, are in this respect of little consequence, which therefore, affords us more liberty in the selection of times to perform the experiment. But it may be rendered much more exact, if it be always performed when the temperature is a little above 32°, and care be taken to have a second calorimeter, in every respect like the first, and charged in the same manner; with this difference only, that no body is put into the inside. Then the quantity of melting ice in this latter calorimeter, will give immediately the effect of the temperature of the air. It only remains to render these two calorimeters such that they may be compared. For that purpose, after being charged they are to be left to drop for some time,

for instance, an hour. The water which they shall have produced, is to be thrown away, and the warm body being introduced into one of them, a new observation is to be made. When the cooling shall have terminated, which is to be judged by the slowness of the melting, the quantities of water formed in the two calorimeters, are to be weighed, and by substracting the one from the other, the difference will express that which the action of the warm body introduced into one of them alone produced; lastly, in order to obtain greater certainty, the experiment may be repeated, putting the warm body into the other calorimeter.

CALP, a species of lime stone, containing clay and oxides of iron.

CAMELEON MINERAL is so named from the readiness with which it passes from one colour to another. It is obtained by melting together potass and black oxide of manganese in a crucible. The solution of this substance in water is at first green, and becomes yellow, and red, and by the addition of a little potass, the solution will again retrograde to green. By adding to the solution a little sulphurous acid or chlorine, it will entirely lose its colour. If an acid be poured into the green solution, it changes to red. By boiling, the excess of potass will be disengaged, and it will become red. Some acids precipitate the manganese, by absorbing the potass and oxygen. Exposure to the air, the addition of gums, or sugar, soda, barytes, or strontites, all have an effect on the cameleon.

CAMPEACHY WOOD. See Logwood.

CAMPHOR. There are two kinds grow in the East, the one produced in the islands of Sumatra and Borneo, and the other produced in Japan and China.

Camphor is extracted from the roots, wood, and leaves of two species of laurus, the roots affording by far the greatest abundance. The method consists in distilling with water in large iron pots, serving as the body of a still, with earthen heads adapted, stuffed with straw, and provided with receivers. Most of the camphor becomes condensed in the solid form among the straw, and part comes over with the water.

The sublimation of camphor is performed in low flat-bottomed glass vessels placed in sand; and the camphor becomes concrete in a pure state against the upper part, whence it is afterwards separated with a knife, after breaking the glass. Lewis asserts, that no addition is requisite in the purification of camphor; but that the chief point consists in managing the fire so that the upper part of the vessel may be hot enough to bake the sublimate together into a kind of cake. Chaptal says, the Hollanders mix an ounce of quicklime with every pound of camphor previous to the distillation.

Purified camphor is a white concrete crystalline substance, not brittle, but easily crumbled, having a peculiar consistence resembling that of spermaceti, but harder. It has a strong lively smell, and an acrid taste; is so volatile as totally to exhale when left exposed in a warm air; is light enough to swim on water; and is very inflammable, burning with a very white flame and smoke, without any residue.

The roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemony, the pasque flower or pulsatilla, and other vegetables, afford camphor by distillation. It is observable, that all these plants afford a much larger quantity of camphor, when the sap has been suffered to pass to the concrete state by several months' drying. Thyme and peppermint, slowly dried, afford much camphor; and Mr. Achard has observed, that a smell of camphor is disengaged when volatile oil of fennel is treated with acids.

Mr. Kind, a German chemist, endeavouring to incorporate muriatic acid gas with oil of turpentine, by putting this oil into the vessels in which the gas was received when extricated, found the oil change first yellow, then brown, and lastly, to be almost wholly coagulated into a crystalline mass, which comported itself in every

respect like camphor. Tromsdorff and Boullay confirm this. A small quantity of camphor may be obtained from oil of turpentine by simple distillation, at a very gentle heat. Other essential oils, however, afford more. By evaporation in shallow vessels, at a heat not exceeding 57° F. Mr. Proust obtained from oil of lavender .25, of sage .21, of marjoram .1014, of rosemary .0625. He conducted the operation on a pretty large scale.

Camphor is not soluble in water in any perceptible degree, though it communicates its smell to that fluid, and may be burned as it floats on its surface. It is said, however, that a surgeon, at Madrid, has effected its solution in water by means of the carbonic acid.

Camphor may be powdered by moistening it with alcohol, and triturating it till dry. It may be formed into an emulsion by previous grinding with near three times its weight of almonds, and afterwards gradually adding the water. Yolk of egg and mucilages are also effectual for this purpose; but sugar does not answer well.

It has been observed by Romieu, that small pieces of camphor floating on water have a rotatory motion.

Alcohol, ethers, and oils, dissolve camphor.

The addition of water to the spirituous or acid solutions of camphor, instantly separates it.

Mr. Hatchett has particularly examined the action of sulphuric acid on camphor. A hundred grains of camphor were digested in an ounce of concentrated sulphuric acid for two days. A gentle heat was then applied, and the digestion continued for two days longer. Six ounces of water were then added, and the whole distilled to dryness. Three grains of an essential oil, having a mixed odour of lavender and peppermint, came over with the water. The residuum being treated twice with two ounces of alcohol each time, fifty three grains of a compact coal in small fragments remained undissolved. The alcohol, being evaporated in a water bath, yielded forty-nine grains of a blackish-brown substance, which was bitter, astringent, had the smell of caromel, and formed a dark brown solution with water. This solution threw down very dark brown precipitates, with sulphate of iron, acetate of lead, muriate of tin, and nitrate of lime. It precipitated gold in the metallic state. Isinglass threw down the whole of what was dissolved in a nearly black precipitate.

When nitric acid is distilled repeatedly in large quantities from camphor, it converts it into a peculiar acid, called camphoric.

Dr. Thomson found a grain of camphor to contains as follows:—

Carbon . .	73.91
Hydrogen .	14.49
Oxygen . .	11.60
	100.00

It melts at 288°, and boils at 400°.

Camphor is used in medicine, but frequently to conceal the preparations employed. When dissolved in acetic acid, it yields, with some essential oil, the aromatic vinegar. Its effluvia are very noxious to insects, on which account, it is put in the cases with preserved or stuffed birds or beasts, to protect them from their ravages.

CAMPHORIC ACID. M. Kosegarten found some years ago, that an acid with peculiar properties was obtained, by distilling nitric acid eight times following from camphor. Bouillon Lagrange has since repeated his experiments, and the following is the account he gives of its preparation and properties.

One part of camphor being introduced into a glass retort, four parts of nitric acid of the strength of 36 degrees are to be poured on it, a receiver adapted to the retort, and all the joints well luted. The retort is then to be placed on a sand heat, and gradually heated. During the process a considerable quantity of nitrous gas, and of carbonic acid gas, is evolved; and part of the camphor is volatilized, while another part seizes the oxygen of the nitric acid. When no more vapours are extricated, the vessels are to be separated, and the sublimed camphor added to the acid that remains in the retort. A like quantity of

nitric acid is again to be poured on this, and the distillation repeated. This operation must be reiterated till the camphor is completely acidified. Twenty parts of nitric acid at 36° are sufficient to acidify one of camphor.

When the whole of the camphor is acidified, it crystallizes in the remaining liquor. The whole is then to be poured out upon a filter, and washed with distilled water, to carry off the nitric acid it may have retained. The most certain indication of the acidification of the camphor is its crystallizing on the cooling of the liquor remaining in the retort.

To purify this acid it must be dissolved in hot distilled water, and the solution, after being filtered, evaporated nearly to half, or till a slight pellicle forms, when the camphoric acid will be obtained in crystals on cooling.

This experiment being too long to be exhibited by the chemical lecturer, its place may be supplied by the following.

A jar is to be filled over mercury with oxygen gas from the chlorate of potash, and a little water passed into it. On the other hand, a bit of camphor and an atom of phosphorus are to be placed in a little cupel; and then one end of a curved tube is to be conveyed under the jar, and the other end under a jar filled with water in the pneumato-chemical apparatus. The apparatus being thus arranged, the phosphorus is to be kindled by means of a red-hot iron. The phosphorus inflames, and afterwards the camphor. The flame produced by the camphor is very vivid; much heat is given out; and the jar is lined with a black substance, which gradually falls down, and covers the water standing on the quicksilver in the jar. This is oxide of carbon. At the same time a gas is collected, that has all the characters of carbonic acid. The water contained in the jar is very fragrant, and contains camphoric acid in solution.

The camphoric acid has a slightly acid, bitter taste, and reddens infusion of litmus.

It crystallizes; and the crystals upon the whole resemble those of muriate of ammonia. (Kosegarten says they are parallelopipeds of a snowy whiteness.) It effloresces on exposure to the atmosphere; is not very soluble in cold water; when placed on burning coals, gives out a thick aromatic smoke, and is entirely dissipated; and with a gentle heat melts, and is sublimed. The mineral acids dissolve it entirely. It decomposes the sulphate and muriate of iron. The fixed and volatile oils dissolve it. It is likewise soluble in alcohol, and is not precipitated from it by water; a property that distinguishes it from the benzoic acid. It unites easily with the earths and alkalis.

To prepare the camphorates of lime, magnesia, and alumina, these earths must be diffused in water, and crystallized camphoric acid added. The mixture must then be boiled, filtered while hot, and the solution concentrated by evaporation.

The camphorate of barytes is prepared by dissolving the pure earth in water, and then adding crystallized camphoric acid.

Those of potash, soda, and ammonia, should be prepared with their carbonates dissolved in water; these solutions are to be saturated with crystallized camphoric acid, heated, filtered, evaporated, and cooled, by which means the camphorates will be obtained.

If the camphoric acid be very pure, they have no smell; if it be not, they have always a slight smell of camphor.

The camphorates of alumina and barytes leave a little acidity on the tongue; the rest have a slightly bitterish taste.

They are all decomposed by heat; the acid being separated and sublimed, and the base remaining pure; that of ammonia excepted, which is entirely volatilized.

If they be exposed to the blowpipe, the acid burns with a blue flame: that of ammonia gives first a blue flame; but toward the end it becomes red.

The camphorates of lime and magnesia are little soluble, the others dissolve more easily.

The mineral acids decompose them all. The alkalis and earths

act in the order of their affinity for the camphoric acid; which is, lime, potash, soda, barytes, ammonia, alumina, magnesia.

Several metallic solutions, and several neutral salts, decompose the camphorates; such as the nitrate of barytes, most of the calcareous salts, &c.

The camphorates of lime, magnesia, and barytes, part with their acid to alcohol.—*Lagrange's Manuel d'un Cours de Chimie.*

CANCER (MATTER OF) was found by Dr. Crawford to give a green colour to syrup of violets, and when treated with sulphuric acid, it gave out a gas resembling sulphuretted hydrogen gas, which he supposed to have existed along with ammonia in the ulcer. He found aqueous chlorine removed the violence of the odour, and he recommends it, therefore, to be used to wash the sores, as likely to have a very salutary effect in mitigating the disorder.

CANNEL COAL. The name of a species found near Whitehaven, and other places in England, and at Gilmerton and Muirkirk, in Scotland. It is massive, of a beautiful velvet greyish black, of specific gravity from 1.23 to 1.27. It has been worked on the lathe into drinking vessels, snuff boxes, and other toys.

CANNON METAL is a composition of copper and tin.

CANTHARIDES, OR SPANISH FLIES, called by Gmelin, the lytta vessicatoria, which has been adopted by the London College of Physicians. From the inspissated watery decoction of these insects treated with alcohol, a resinous matter is obtained; which is supposed to be the blistering principle. If a few grains only be taken into the stomach, they act as a poison, producing satyriasis, delirium, convulsions, and death. Oils, milk, syrups, friction of the spine, with volatile liniment and laudanum, and draughts containing opium, and camphorated emulsion, are the best antidotes.

CANTON'S PHOSPHORUS is thus prepared. Calcine oyster shells in the open fire for a half an hour, then select the whitest and the largest pieces, and mix them with one-third of their weight of flour of sulphur, pack the mixture closely into a covered crucible, and heat it to redness for an hour. When the whole is cooled, select the whitest pieces for use.

CAOUTCHOUC. This substance which has been improperly termed *elastic gum*, and vulgarly, from its common application to rub out pencil marks on paper, *Indian rubber*, is obtained from the milky juice of different plants in hot countries. The chief of these are the Jatropha elastica, and Urceola elastica.

The juice is applied in successive coatings on a mould of clay, and dried by the fire or in the sun; and when of a sufficient thickness, the mould is crushed, and the pieces shaken out. Acids separate the caoutchouc from the thinner part of the juice at once by coagulating it. The juice of old plants yields nearly two-thirds of its weight; that of younger plants less. Its colour, when fresh, is yellowish white, but it grows darker by exposure to the air.

The elasticity of this substance is its most remarkable property: when warmed, as by immersion in hot water, slips of it may be drawn out to seven or eight times their original length, and will return to their former dimensions nearly. Cold renders it stiff and rigid, but warmth restores its original elasticity. Exposed to the fire it softens, swells up, and burns with a bright flame. In Cayenne it is used to give light as a candle. Its solvents are ether, volatile oils, and petroleum. The ether, however, requires to be washed with water repeatedly, and in this state it dissolves it completely. Pelletier recommends to boil the caoutchouc in water for an hour; then to cut it into slender threads; to boil it again about an hour; and then to put it into rectified sulphuric ether, in a vessel close stopped. In this way he says it will be totally dissolved in a few days, without heat, except the impurities, which will fall to the bottom, if ether enough be employed. Berniard says, the nitrous ether dissolves it better than the sulphuric. If this solution be spread

on any substance, the ether evaporates very quickly, and leaves a coating of caoutchouc unaltered in its properties. Naphtha, or petroleum, rectified into a colourless liquid, dissolves it, and likewise leaves it unchanged by evaporation. Oil of turpentine softens it, and forms a pasty mass, that may be spread as a varnish, but is very long in drying. A solution of caoutchouc in five times its weight of oil of turpentine, and this solution dissolved in eight times its weight of drying linseed oil by boiling, is said to form the varnish of air-balloons. Alkalis act upon it so as in time to destroy its elasticity. Sulphuric acid is decomposed by it; sulphurous acid being evolved, and the caoutchouc converted into charcoal. Nitric acid acts upon it with heat; nitrous gas being given out, and oxalic acid crystallizing from the residuum. On distillation it gives out ammonia, and carburetted hydrogen.

Caoutchouc may be formed into various articles without undergoing the process of solution. If it be cut into a uniform slip of a proper thickness, and wound spirally round a glass or metal rod, so that the edges shall be in close contact, and in this state be boiled for some time, the edges will adhere so as to form a tube. Pieces of it may be readily joined by touching the edges with the solution in ether: but this is not absolutely necessary, for, if they be merely softened by heat, and then pressed together, they will unite very firmly.

If linseed oil be rendered very drying by digesting it upon an oxide of lead, and afterward applied with a small brush on any surface, and dried by the sun or in the smoke, it will afford a pellicle of considerable firmness, transparent, burning like caoutchouc, and wonderfully elastic. A pound of this oil, spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of caoutchouc: it was used to make catheters and bougies, to varnish balloons, and for other purposes.

Of the mineral caoutchouc there are several varieties: 1. Of a blackish-brown inclining to olive, soft, exceedingly compressible, unctuous, with a slightly aromatic smell. It burns with a bright flame, leaving a black oily residuum, which does not become dry. 2. Black, dry, and cracked on the surface, but, when cut into, of a yellowish-white. A fluid resembling pyrolignic acid exudes from it when recently cut. It is pellucid on the edges, and nearly of a hyacinthine red colour. 3. Similar to the preceding, but of a somewhat firmer texture, and ligneous appearance, from having acquired consistency in repeated layers. 4. Resembling the first variety, but of a darker colour, and adhering to gray calcareous spar with some grains of galena. 5. Of a liver-brown colour, having the aspect of the vegetable caoutchouc, but passing by gradual transition into a brittle bitumen, of vitreous lustre, and a yellowish colour. 6. Dull reddish-brown, of a spongy or cork-like texture, containing blackish-grey nuclei of impure caoutchouc. Many more varieties are enumerated.

One specimen of this caoutchouc has been found in a petrified marine shell enclosed in a rock, and another enclosed in crystallized fluor spar.

The mineral caoutchouc resists the action of solvents still more than the vegetable. The rectified oil of petroleum affects it most, particularly when by partial burning it is resolved into a pitchy viscous substance. A hundred grains of a specimen analyzed in the dry way by Klaproth, afforded carburetted hydrogen gas 38 cubic inches, carbonic acid gas 4, bituminous oil 73 grains, acidulous phlegm 1.5, charcoal 6.25, lime 2, silex 1.5, oxide of iron .75, sulphate of lime .5, alumina .25.

Caoutchouc has been applied to preserve the surface of iron goods from oxidation by the action of the atmosphere, for which it is well adapted, as it does not undergo any change in the air. It acquires a treacley consistence under ordinary degrees of heat, adheres firmly to iron or steel, and is easily removed by a soft rag and a piece of bread. The most

useful application of this property is to preserve the surface of engraved steel blocks and plates. When mixed with oil of turpentine it is more easily applied.

CARAT. We constantly hear of gold being so many carats fine, as 22 carats for example; that means that in one pennyweight, which is 24 grains, there are 22 grains of pure gold, and 2 grains of alloy. If gold be said to be 19 carats fine, there are 19 grains of pure gold, and 5 of alloy, in the 24.

CARBON. When vegetable matter, particularly the more solid, as wood, is exposed to heat in close vessels, the volatile parts fly off, and leave behind a black porous substance which is charcoal. If this be suffered to undergo combustion in contact with oxygen, or with atmospheric air, much the greater part of it will combine with the oxygen, and escape in the form of gas; leaving about a two-hundredth part, which consists chiefly of different saline and metallic substances. This pure inflammable part of the charcoal is what is commonly called *carbon*; and if the gas be received into proper vessels, the carbon will be found to have been converted by the oxygen into an acid, called the carbonic.

From the circumstance, that inflammable substances refract light, in a ratio greater than that of their densities, Newton inferred that the diamond was inflammable. The quantity of the inflammable part of charcoal requisite to form a hundred parts of carbonic acid, was calculated by Lavoisier to be twenty-eight parts. From a careful experiment of Mr. Tennant, 27.6 parts of diamond, and 72.4 of oxygen, formed 100 of carbonic acid; and hence he inferred the identity of diamond, and the inflammable part of charcoal.

Well-burned charcoal is a conductor of electricity, though wood, simply deprived of its moisture by baking, is a nonconductor; but it is a very bad conductor of caloric, a property of considerable use on many occasions, as in lining crucibles.

It is insoluble in water, and hence the utility of charring the surface of wood exposed to that liquid, in order to preserve it, a circumstance not unknown to the ancients. This preparation of timber has been proposed as an effectual preventive of what is commonly called the dry rot. It has an attraction, however, for a certain portion of water, which it retains very forcibly. Heated red-hot, or nearly so, it decomposes water; forming with its oxygen carbonic acid, or carbonic oxide, according to the quantity present; and with the hydrogen a gaseous carburet, called carburetted hydrogen, or heavy inflammable air.

Charcoal is infusible by any heat. If exposed to a very high temperature in close vessels it loses little or nothing of its weight, but shrinks, becomes more compact, and acquires a deeper black colour.

Recently prepared charcoal has a remarkable property of absorbing different gases, and condensing them in its pores, without any alteration of their properties or its own.

Charcoal has a powerful affinity for oxygen, whence its use in disoxygenating metallic oxides, and restoring their base to its original metallic state, or reviving the metal. Thus too it decomposes several of the acids, as the phosphoric and sulphuric, from which it abstracts their oxygen, and leaves the phosphorus and sulphur free.

Carbon is capable of combining with sulphur and with hydrogen. With iron it forms steel; and it unites with copper into a carburet, as observed by Dr. Priestley.

A singular and important property of charcoal is that of destroying the smell, colour, and taste of various substances: for the first accurate experiments on which we are chiefly indebted to Mr. Lowitz of Petersburgh, though it had been long before recommended to correct the fœtor of foul ulcers, and as an antiseptic. On this account it is certainly the best dentifrice. Water that has become putrid by long keeping in wooden casks, is rendered sweet by filtering through charcoal powder, or by agitation with it; particularly if a few drops

of sulphuric acid be added. Common vinegar boiled with charcoal powder becomes perfectly limpid. Saline solutions, that are tinged yellow or brown, are rendered colourless in the same way, so as to afford perfectly white crystals. The impure carbonate of ammonia obtained from bones, is deprived both of its colour and fetid smell by sublimation with an equal weight of charcoal powder. Malt spirit is freed from its disagreeable flavour by distillation from charcoal; but if too much be used, part of the spirit is decomposed. Simple maceration, for eight or ten days, in the proportion of about 1-150th of the weight of the spirit, improves the flavour much. It is necessary, that the charcoal be well burned, brought to a red heat before it is used, and used as soon as may be, or at least be carefully excluded from the air. The proper proportion too should be ascertained by experiment on a small scale. The charcoal may be used repeatedly, by exposing it for some time to a red heat before it is again employed.

Charcoal is used on particular occasions as fuel, on account of its giving a strong and steady heat without smoke. It is employed to convert iron into steel by cementation. It enters into the composition of gunpowder. In its finer states, as in ivory black, lamp-black, &c. it forms the basis of black paints, Indian ink, and printers' ink.

The purest carbon for chemical purposes is obtained by strongly igniting lamp-black in a covered crucible. This yields, like the diamond, unmixed carbonic acid by combustion in oxygen.

Carbon unites with all the common simple combustibles, and with azote, forming a series of most important compounds. With sulphur it forms a curious limpid liquid called carburet of sulphur, or sulphuret of carbon. With phosphorus it forms a species of compound, whose properties are imperfectly ascertained. It unites with hydrogen in two definite proportions, constituting subcarburetted and carburetted hydrogen gases. With azote it forms prussic gas, the cyanogen of M. Gay Lussac. Steel and plumbago are two different compounds of carbon with iron. In black chalk we find this combustible intimately associated with silica and alumina. The primitive combining proportion, or prime equivalent of carbon, is 0.75 on the oxygen scale.

For experiments carbon may be obtained by strongly igniting lamp-black in a crucible.

The diamond consists of pure carbon. See DIAMOND.

CARBON MINERAL is found in small quantities in beds of coal. It has a silky lustre and fibrous texture of wood. It consists of charcoal with various proportions of earth and iron, and is free from bitumen.

CARBONATES are compounds of carbonic acid with earths, alkalis, and metallic oxides. They are very abundant in nature, and some account of them will be found under the specific articles with which carbonic acid combines, and also under carbonic acid.

CARBONATE OF BARYTES. See HEAVY SPAR.

CARBONATE OF LIME. See CALCAREOUS SPAR.

CARBONATE OF STRONTIAN. See STRONTIAN and HEAVY SPAR.

CARBONIC ACID. This acid, being a compound of carbon and oxygen, may be formed by burning charcoal; but as it exists in great abundance ready formed, it is not necessary to have recourse to this expedient. All that is necessary is to pour sulphuric acid, diluted with five or six times its weight of water, on common chalk, which is a compound of carbonic acid and lime. An effervescence ensues; carbonic acid is evolved in the state of gas, and may be received in the usual manner.

As the rapid progress of chemistry during the latter part of the 18th century, was in a great measure owing to the discovery of this acid, it may be worth while to trace the history of it somewhat particularly.

Paracelsus and Van Helmont were acquainted with the fact, that air is extricated from solid bodies

during certain processes; and the latter gave to air thus produced the name of gas. Boyle called these kinds of air artificial airs, and suspected that they might be different from the air of the atmosphere. Hales ascertained the quantity of air that could be extricated from a great variety of bodies, and showed that it formed an essential part of their composition. Dr. Black proved, that the substances then called lime, magnesia, and alkalis, were compounds, consisting of a peculiar species of air, and pure lime, magnesia, and alkali. To this species of air he gave the name of fixed air, because it existed in those bodies in a fixed state. This air or gas was afterwards investigated, and a great number of its properties ascertained, by Dr. Priestley. From these properties Mr. Keir first concluded that it was an acid; and this opinion was soon confirmed by the experiments of Bergman, Fontana, and others. Dr. Priestley at first suspected that this acid entered as an element into the composition of atmospherical air; and Bergman, adopting the same opinion, gave it the name of aërial acid. Mr. Bewley called it mephitic acid, because it could not be respired without occasioning death; and this name was also adopted by Morveau. Mr. Keir called it calcareous acid; and at last M. Lavoisier, after discovering its composition, gave it the name of carbonic acid gas.

The opinions of chemists concerning the composition of carbonic acid have undergone as many revolutions as its name. Dr. Priestley and Bergman seem at first to have considered it as an element; and several celebrated chemists maintained that it was the acidifying principle. Afterwards it was discovered to be a compound, and that oxygen gas was one of its component parts. Upon this discovery the prevalent opinion of chemists was, that it consisted of oxygen and phlogiston; and when hydrogen and phlogiston came, according to Mr. Kirwan's theory, to signify the same thing, it was of course maintained that carbonic acid was composed of oxygen and hydrogen: and though M. Lavoisier demonstrated that it was formed by the combination of carbon and oxygen, this did not prevent the old theory from being maintained; because carbon was itself considered as a compound, into which a very great quantity of hydrogen entered. But after M. Lavoisier had demonstrated, that the weight of the carbonic acid produced was precisely equal to the charcoal and oxygen employed; after Mr. Cavendish had discovered, that oxygen and hydrogen when combined did not form carbonic acid, but water, it was no longer possible to doubt that this acid was composed of carbon and oxygen. Accordingly, all farther dispute about it is at an end.

If any thing were still wanting, to put this conclusion beyond the reach of doubt, it was to decompose carbonic acid, and thus to exhibit its component parts by analysis as well as synthesis. This has been actually done by Mr. Tennant. Into a tube of glass he introduced a bit of phosphorus and some carbonate of lime. He then sealed the tube hermetically, and applied heat. Phosphate of lime was formed, and a quantity of charcoal deposited. Now phosphate of lime is composed of phosphoric acid and lime, and phosphoric acid is composed of phosphorus and oxygen. The substances introduced into the tube were phosphorus, lime, and carbonic acid, and the substances found in it were phosphorus, lime, oxygen, and charcoal. The carbonic acid, therefore, must have been decomposed, and it must have consisted of oxygen and charcoal. This experiment was repeated by Dr. Pearson, who ascertained that the weight of the oxygen and charcoal together was equal to that of the carbonic acid which had been introduced; and in order to show that it was the carbonic acid which had been decomposed, he introduced pure lime and phosphorus; and, instead of phosphate of lime and carbon, he got nothing but phosphuret of lime. These experiments were also confirmed by Fourcroy, Vauquelin, Sylvestre,

and Brongniart. Count Mussin-Puschkin too boiled a solution of carbonate of potash on purified phosphorus, and obtained charcoal. This he considered as an instance of the decomposition of carbonic acid, and as a confirmation of the experiments above related.

Carbonic acid abounds in great quantities in nature, and appears to be produced in a variety of circumstances. It composes $\frac{44}{100}$ of the weight of limestone, marble, calcareous spar, and other natural specimens of calcareous earth, from which it may be extricated either by the simple application of heat, or by the superior affinity of some other acid; most acids having a stronger action on bodies than this. This last process does not require heat, because fixed air is strongly disposed to assume the elastic state. Water, under the common pressure of the atmosphere, and at a low temperature, absorbs somewhat more than its bulk of fixed air, and then constitutes a weak acid. If the pressure be greater, the absorption is augmented. It is to be observed, likewise, that more gas than water will absorb, should be present. Heated water absorbs less; and if water impregnated with this acid be exposed on a brisk fire, the rapid escape of the aerial bubbles affords an appearance as if the water were at the point of boiling, when the heat is not greater than the hand can bear. Congelation separates it readily and completely from water; but no degree of cold or pressure has yet exhibited this acid in a dense or concentrated state of fluidity.

Carbonic acid gas is much denser than common air, and for this reason occupies the lower parts of such mines or caverns as contain materials which afford it by decomposition. The miners call it choke-damp. The Grotto del Cane, in the kingdom of Naples, has been famous for ages on account of the effects of a stratum of fixed air which covers its bottom. It is a cave or hole in the side of a mountain, near the lake Agnano, measuring not more than eighteen feet from its entrance to the inner extremity; where if a dog or other animal, that holds down its head, be thrust, it is immediately killed by inhaling this noxious fluid.

Carbonic acid gas is emitted in large quantities by bodies in the state of the vinous fermentation, and on account of its great weight, it occupies the apparently empty space or upper part of the vessels in which the fermenting process is going on. A variety of striking experiments may be made in this stratum of elastic fluid. Lighted paper, or a candle dipped into it, is immediately extinguished; and the smoke remaining in the carbonic acid gas renders its surface visible, which may be thrown into waves by agitation like water. If a dish of water be immersed in this gas, and briskly agitated, it soon becomes impregnated, and obtains the pungent taste of Pyrmont water. In consequence of the weight of the carbonic acid gas, it may be lifted out in a pitcher, or bottle, which, if well corked, may be used to convey it to great distances, or it may be drawn out of a vessel by a cock like a liquid. The effects produced by pouring this invisible fluid from one vessel to another, have a very singular appearance; if a candle or small animal be placed in a deep vessel, the former becomes extinct, and the latter expires in a few seconds, after the carbonic acid gas is poured upon them, though the eye is incapable of distinguishing any thing that is poured. If, however, it be poured into a vessel full of air, in the sunshine, its density being so much greater than that of the air, renders it slightly visible by the undulations of and streaks it forms in this fluid, as it descends through it.

Carbonic acid reddens infusion of litmus; but the redness vanishes by exposure to the air, as the acid flies off. It has a peculiar sharp taste, which may be perceived over vats in which wine or beer is fermenting, as also in sparkling Champaign, and the brisker kinds of cider. Light passing through it is refracted by it, but does not effect any sensible alteration in it,

though it appears, from experiment, that it favours the separation of its principles by other substances. It will not unite with an over dose of oxygen, of which it contains 72 parts in 100, the other 28 being pure carbon. It not only destroys life, but the heart and muscles of animals killed by it lose all their irritability, so as to be insensible to the stimulus of galvanism.

Carbonic acid is dilated by heat, but not otherwise altered by it. It is not acted upon by oxygen, or any of the simple combustibles. Charcoal absorbs it, but gives it out again unchanged, at ordinary temperatures; but when this gaseous acid is made to traverse charcoal ignited in a tube, it is converted into carbonic oxide. Phosporus is insoluble in carbonic acid gas; but, as already observed, is capable of decomposing it by compound affinity, when assisted by sufficient heat; and Priestley and Cruikshank have shewn that iron, zinc, and several other metals, are capable of producing the same effect. If carbonic acid be mixed with sulphuretted, phosphuretted, or carburetted gas, it renders them less combustible, or destroys their combustibility entirely, but produces no other sensible change. Such mixtures occur in various analyses, and particularly in the products of the decomposition of vegetable and animal substances. The inflammable air of marshes is frequently carburetted hydrogen intimately mixed with carbonic acid gas, and the sulphuretted hydrogen gas obtained from mineral waters is very often mixed with it.

Carbonic acid appears from various experiments of Ingenhousz to be of considerable utility in promoting vegetation. It is probably decomposed by the organs of plants, its base furnishing part at least of the carbon that is so abundant in the vegetable kingdom, and its oxygen contributing to replenish the atmosphere with that necessary support of life, which is continually diminishing by the respiration of animals and other causes.

The specific gravity of carbonic acid is about $1\frac{1}{2}$ that of common atmospheric air.

CARBONIC OXIDE is a gaseous compound, consisting of one prime equivalent of oxygen and one of carbon, and the former being 1.0, the latter is 0.75, therefore the prime equivalent of the compound is 1.75, which is the same as nitrogen. This gas cannot be procured by exposing oxygen and carbon to a great heat, for in this case the carbon absorbs the full quantity of oxygen and carbonic acid gas is the result. Carbonic oxide may be obtained by exposing a mixture of dry earthy chalk with iron or zinc filings to great heat in a gun-barrel or iron retort.

This gas burns at a low temperature with a dark blue flame.

CARBUNCLE is a gem which was highly valued by the ancients, and is supposed to be the alamandine, a variety of garnet.

CARBURETS are carbon and other bodies united together.

CARBURET OF SULPHUR is a liquid consisting of carbon and sulphur. It is also called sulphuret of carbon, and alcohol of sulphur. It is obtained by passing sulphur over red hot charcoal. When pure it is transparent and colourless. Its specific gravity is 1.272. It boils at 106°, and does not freeze at $-80°$. It is very volatile, and has a pungent taste and peculiar fetid odour. It is inflammable, and when burned with oxygen produces sulphurous and carbonic acids. It consists of one proportion of charcoal and two of sulphur, $5.7 + 30 = 35.7$. It was discovered by Lampadius, who called it alcohol of sulphur.

CARBURETTED HYDROGEN GAS. Of this compound gas we have two species. The first consisting of 1 prime equivalent of each, is carburetted hydrogen; the second, of 1 prime of carbon and 2 of hydrogen, is subcarburetted hydrogen. Carburetted hydrogen is the percarburetted hydrogen of the French chemists. To prepare it, we mix in a glass retort, 1 part of alcohol and 4 of sulphuric acid, and expose the retort to a moderate heat. The gas is usually

received over water. It is destructive of animal life. Its specific gravity is 0.978. It possesses all the mechanical properties of air. It is invisible, and void of taste and smell, when it has been washed from a little ethereous vapour. When passed through a porcelain tube, heated to a cherry red, it lets fall a portion of charcoal, and nearly doubles its volume. At a higher temperature it deposits more charcoal, and augments; and at the greatest heat it lets fall almost the whole of its carbon, and assumes a volume 3½ times greater than it had at first.

Carburetted hydrogen burns with a splendid white flame. When mixed with three times its bulk of oxygen, and kindled by a taper or the electric spark, it explodes, and the four volumes are converted into two of carbonic acid. But two volumes of carbonic acid contain two of oxygen. The remaining volume of oxygen therefore has been expended in forming water with two volumes of hydrogen.

When this gas is mixed with its own bulk of chlorine, the gaseous mixture is condensed over water into a peculiar oily looking compound. Hence this carburetted hydrogen was called by its discoverers, the associated Dutch chemists, *olefiant gas*.

Olefiant gas is elegantly analyzed by heating sulphur in it over mercury. One cubic inch of it, with 2 grains of sulphur, yields 2 of sulphuretted hydrogen, and charcoal is deposited. Now we know that the latter gas contains just its own volume of hydrogen.

2. Subcarburetted hydrogen. This gas is procured from the mud of stagnant ditches. Fill a wide mouthed goblet with water, and inverting it in the ditch-water, stir the bottom with a stick. Gas rises into the goblet.

The fire-damp of mines is a similar gas to that of ditches.

Subcarburetted hydrogen is destitute of colour, taste, and smell. It burns with a yellow flame, like that of a candle.

As the gas of ditches and the choke-damp of mines is evidently derived from the action of water on decaying vegetable or carbonaceous matter, we can understand that a similar product will be obtained by passing water over ignited charcoal, or by heating moistened charcoal or vegetable matter in retorts.

CARICA PAPAYA. Papaw tree. Every part of the papaw tree, except the ripe fruit, affords a milky juice, which is used in the Isle of France as an effectual remedy for the tape worm. In Europe, however, whither it has been sent in the concrete state, it has not answered.

The most remarkable circumstance regarding the papaw tree, is the extraction from its juice of a matter exactly resembling the flesh or fibre of animals, and hence called vegetable *fibrin*, which see.

CARMINE, a pigment obtained from cochineal, and is one of those called lake. See LAKE.

CARNELIAN, a kind of calcedony, softer than the common calcedony. Its colours are white, yellow, brown, and red. Specific gravity 2.6. It consists of silica 94, alumina 3.5, and some oxides of iron. The best carnelians are found in Hindoostan, in the beds of torrents. They are at first of a black olive, passing into grey, but after being some weeks exposed to the sun, and then heated in earthen pots, they acquire the beautiful shades for which they are highly valued by the jewellers.

CAROMEL, the smell of sugar when at a calcining heat.

CARTHAMUS, SAFFLOWER, OR BASTARD SAFFRON. In some of the deep reddish, yellow, or orange-coloured flowers, the yellow matter seems to be of the same kind with that of the pure yellow flowers; but the red to be of a different kind from the pure red ones. Watery menstrua take up only the yellow, and leave the red, which may afterwards be extracted by alcohol, or by a weak solution of alkali. Such particularly are the saffron coloured flowers of carthamus. These, after the yellow matter has been extracted by water, are said to give a tincture to ley; from which, on standing at rest for some time, a deep red fe-

cula subsidos, called saf-flower, and from the countries whence it is commonly brought to us, Spanish red and China lake. This pigment impregnates alcohol with a beautiful red tincture; but communicates no colour to water.

Rouge is prepared from carthamus. For this purpose the red colour is extracted by a solution of the subcarbonate of soda, and precipitated by lemon juice, previously depurated by standing. This precipitate is dried on earthen plates, mixed with talc, or French chalk, reduced to a powder by means of the leaves of shave-grass, triturated with it till they are both very fine, and then sifted. The fineness of the powder and proportion of the precipitate constitute the difference between the finer and cheaper rouge. It is likewise spread very thin on saucers, and sold in this state for dying.

Carthamus is used for dying silk of a poppy, cherry, rose, or bright orange red. After the yellow matter is extracted as above, and the cakes opened, it is put into a deal trough, and sprinkled at different times with pearl ashes, or rather soda well powdered and sifted, in the proportion of six pounds to a hundred, mixing the alkali well as it is put in. The alkali should be saturated with carbonic acid. The carthamus is then put on a cloth in a trough with a grated bottom, placed on a larger trough, and cold water poured on, till the large trough is filled. And this is repeated, with the addition of a little more alkali toward the end, till the carthamus is exhausted and become yellow. Lemon juice is then poured into the bath, till it is turned of a fine cherry colour, and after it is well stirred the silk is immersed in it. The silk is wrung, drained, and passed through fresh baths, washing and drying after every operation, till it is of a proper colour; when it is brightened in hot water and lemon juice. For a poppy or fire colour a slight annotta ground is first given; but the silk should not be alumed. For a pale carnation a little soap should be put into the bath. All these baths must be used as soon as they are made; and cold, because heat destroys the colour of the red fecula.

CARTILAGE. If the bones be digested in muriatic acid for some time, the salts of lime, of which they are composed, will be dissolved, and there will remain a substance of only one-third the weight, elastic, and resembling albumen. In a very young animal the bones merely consist of cartilage, and the calcareous salts are deposited in it, and thereby they become more solid and strong. When children are attacked by the disease called rachitis, or rickets, the calcareous salts are absorbed, and the bones become cartilaginous. Hence their weakness and the distortions which result from this disease. Cartilage with nitric acid becomes gelatin. Alkalis convert it into animal soap.

CASE-HARDENING. Steel when hardened is brittle, and iron alone is not capable of receiving the hardness steel may be brought to possess. There is nevertheless a variety of articles in which it is desirable to possess all the hardness of steel, together with the toughness of iron. These requisites are united in the art of case-hardening, which does not differ from the making of steel, except in the shorter duration of the process. Tools, utensils, or ornaments intended to be polished, are first manufactured in iron and nearly finished, after which they are put into an iron box, together with vegetable or animal coals in powder, and cemented for a certain time. This treatment converts the external part into a coating of steel, which is usually very thin, because the time allowed for the cementation is much shorter than when the whole is intended to be made into steel. Immersion of the heated pieces into water hardens the surface, which is afterward polished by the usual methods. Moxon's Mechanic Exercises, p. 56, gives the following receipt:—Cow's horn or hoof is to be baked or thoroughly dried, and pulverized. To this add an equal quantity of bay salt: mix them with stale chamber-ley, or white wine

vinegar: cover the iron with this mixture, and bed it in the same in loam, or enclose it in an iron box: lay it then on the hearth of the forge to dry and harden: then put it into the fire, and blow till the lump have a blood-red heat, and no higher, lest the mixture be burned too much. Take the iron out, and immerse it in water to harden.

CASEIC ACID. A name given by Proust to a substance he found in cheese, and to which he ascribes its flavour.

CASSAVA is an American plant called also Juca, and is in botany the jatropha manihat.

There are two sorts used as food in Mexico and South America, the sweet and bitter. The root of the latter, in its raw state, is poisonous, but by expressing the juice, or by roasting, it is rendered innocent, and furnishes a very agreeable farina, which is converted into bread. The sweet juca answers the same purpose. The bread is very nutritive from its containing a great deal of sugar. The negroes often poison themselves with the bitter juice. It has been used to poison their arrows. The roots come to perfection seven or eight months after planting. Cassava is most useful to the Americans.—*Humboldt*.

CASSIUS'S PURPLE PRECIPITATE is obtained by immersing a plate of tin in a solution of gold, when a purple powder is precipitated, which is used to paint enamel.

CASTOR. A soft greyish-yellow or light brown substance, found in four bags in the inguinal region of the beaver. In a warm air it grows by degrees hard and brittle, and of a darker colour, especially when dried in chimneys, as is usually done. According to Bouillon La Grange, it consists of a mucilage, a bitter extract, a resin, an essential oil, in which its peculiar smell appears to reside, and a flaky crystalline matter, much resembling the adipocere of biliary calculi.

Castor is regarded as a powerful antispasmodic.

CATECHU. A brown astringent substance formerly known by the name of *Japan earth*. It is a dry extract, prepared from the wood of a species of sensitive plant, the *mimosa catechu*. It is imported into this country from Bombay and Bengal. According to Sir H. Davy, who analyzed it, that from Bombay is of uniform texture, red-brown colour, and specific gravity 1.39: that from Bengal is more friable and less consistent, of a chocolate colour externally, but internally chocolate, streaked with red-brown; and specific gravity 1.28. The catechu from either place differs little in its properties. Its taste is astringent, leaving behind a sensation of sweetness. It is almost wholly soluble in water.

Two hundred grains of picked catechu from Bombay afforded 109 grains of tannin, 68 extractive matter, 13 mucilage, 10 residuum, chiefly sand and calcareous earth. The same quantity from Bengal: tannin 97 grains, extractive matter 73, mucilage 16, residual matter, being sand, with a small quantity of calcareous and aluminous earths, 14. Of the latter the darkest parts appeared to afford most tannin, the lightest most extractive matter. The Hindoos prefer the lightest coloured, which has probably most sweetness, to chew with the betel-nut.

Of all the astringent substances we know, catechu appears to contain the largest proportion of tannin, and Mr. Purkis found, that one pound was equivalent to seven or eight of oak bark for the purpose of tanning leather.

As a medicine it has been recommended as a powerful astringent, and a tincture of it is used for this purpose, but its aqueous solution is less irritating. Made into troches with gum arabic and sugar it is an elegant preparation, and in this way is said much to assist the clearness of the voice, and to be remarkably serviceable in disorders of the throat.

CAT'S EYE, a beautiful mineral brought from Ceylon, which has been thus named from a peculiar play of light arising from white fibres interspersed. Its constituent parts are 95 silica, 1.75 alumina, 1.5 lime, and 0.25 oxide of iron.

CAUSTIC (LUNAR) is formed from a solution of silver in nitric acid, which deposits the crystals as it cools by evaporation. These fused by a gentle heat, and cast into small sticks in a mould, form the lunar caustic, or lapis infernalis, of the surgeons. They burn animal matter, and are used for that purpose. Luna, or the moon, was a symbol of the alchemists *for* silver caustic. Pure soda, or kali purum, is employed as a caustic. It must be kept in a bottle from which moisture is excluded.

CAUSTICITY. All substances which have so strong a tendency to combine with the principles of organized substances, as to destroy their texture, are said to be caustic. The chief of these are the concentrated acids, pure alkalis, and the metallic salts.

CAUTERY (POTENTIAL) another name for caustic.

CAWK. A term by which the miners distinguish the opaque specimens of sulphate of barytes.

CELESTINE. Native sulphate of strontites, is so named from its occasional delicate blue colour; though it is frequently found white, greyish, and yellowish-white, and red. It occurs both massive and crystallized. Sometimes also in fibrous and stellated forms. According to Hauy, the primitive form is a right rhomboidal prism, of 104° 48' and 75° 12'. It has a shining lustre, and is either transparent, translucent, or opaque. It scratches calcareous spar, but is scratched by fluor. Its specific gravity is 3.6. Before the blow pipe it fuses into a white, opaque, and friable enamel.

CEMENT. Whatever is employed to unite or cement together things of the same or different kinds, may be called a *cement*. In this sense it includes LUTES, GLUES, and SOLDERS of every kind, which see; but it is more commonly employed to signify those of which the basis is an earth or earthy salt. See LIME. We shall here enumerate, chiefly from the Philosophical Magazine, some cements that are used for particular purposes.

Seven or eight parts of resin, and one of wax, melted together, and mixed with a small quantity of plaster of Paris, is a very good cement to unite pieces of Derbyshire spar, or other stone. The stone should be made hot enough to melt the cement, and the pieces should be pressed together as closely as possible, so as to leave as little as may be of the cement between them. This is a general rule in cementing, as the thinner the stratum of cement interposed, the firmer it will hold.

Melted brimstone, used in the same way, will answer sufficiently well, if the joining be not required to be very strong.

It sometimes happens that jewellers, in setting precious stones, break off pieces by accident; in this case they join them so that it cannot easily be seen, with gum mastic, the stone being previously made hot enough to melt it. By the same medium cameos of white enamel or coloured glass are often joined to a real stone as a ground, to produce the appearance of an onyx. Mastic is likewise used to cement false backs or doublets to stones, to alter their hue.

The jewellers in Turkey, who are generally Armenians, ornament watch-cases and other trinkets with gems, by gluing them on. The stone is set in silver or gold, and the back of the setting made flat to correspond with the part to which it is to be applied. It is then fixed on with the following cement. Isinglass, soaked in water till it swells up and becomes soft, is dissolved in French brandy, or in rum, so as to form a strong glue. Two small bits of gum galbanum, or gum ammoniacum, are dissolved in two ounces of this by trituration; and five or six bits of mastic, as big as peas, being dissolved in as much alcohol as will render them fluid, are to be mixed with this by means of a gentle heat. This cement is to be kept in a phial closely stopped; and when used, it is to be liquefied by immersing the phial in hot water. This cement resists moisture.

A solution of shell lac in alcohol, added to a solution of isinglass in

proof spirit, makes another cement that will resist moisture.

So does common glue melted without water, with half its weight of resin, with the addition of a little red ochre to give it a body. This is particularly useful for cementing hones to their frames.

If clay and oxide of iron be mixed with oil, according to Mr. Gad, of Stockholm, they will form a cement that will harden under water.

A strong cement, insoluble in water, may be made from cheese. The cheese should be that of skimmed milk, cut into slices, throwing away the rind, and boiled till it becomes a strong glue, which however does not dissolve in the water. This water being poured off, it is to be washed in cold water, and then kneaded in warm water. This process is to be repeated several times. The glue is then to be put warm on a levigating stone, and kneaded with quicklime. This cement may be used cold, but it is better to warm it; and it will join marble, stone, or earthenware, so that the joining is scarcely to be discovered.

Boiled linseed oil, litharge, red lead, and white lead, mixed together to a proper consistence, and applied on each side of a piece of flannel, or even linen or paper, and put between two pieces of metal before they are brought home, or close together, will make a close and durable joint, that will resist boiling water or even a considerable pressure of steam. The proportions of the ingredients are not material, but the more the red lead predominates, the sooner the cement will dry, and the more the white lead the contrary. This cement answers well for joining stones of any dimensions.

The following is an excellent cement for iron, as in time it unites with it into one mass. Take two ounces of muriate of ammonia, one of flowers of sulphur, and 16 of cast-iron filings or borings. Mix them well in a mortar, and keep the powder dry. When the cement is wanted for use, take one part of this mixture, twenty parts of clear iron borings or filings, grind them together in a mortar, mix them with water to a proper consistence, and apply them between the joints.

Powdered quicklime mixed with bullock's blood is often used by coppersmiths, to lay over the rivets and edges of the sheets of copper in large boilers, as a security to the junctures, and also to prevent cocks from leaking.

Six parts of clay, one of iron filings, and linseed oil sufficient to form a thick paste, make a good cement for stopping cracks in iron boilers.

Temporary cements are wanted in cutting, grinding, or polishing optical glasses, stones, and various small articles of jewellery, which it is necessary to fix on blocks, or handles, for the purpose. Four ounces of resin, a quarter of an ounce of wax, and four ounces of whiting made previously red-hot, form a good cement of this kind; as any of the above articles may be fastened to it by heating them, and removed at pleasure in the same manner, though they adhere very firmly to it when cold. Pitch, resin, and a small quantity of tallow, thickened with brick-dust, is much used at Birmingham for these purposes. Four parts of resin, one of bees wax, and one of brick dust, likewise make a good cement. This answers extremely well for fixing knives and forks in their hafts; but the manufacturers of cheap articles of this kind, too commonly use resin and brick-dust alone. On some occasions, in which a very tough cement is requisite, that will not crack though exposed to repeated blows, as in fastening to a block metallic articles that are to be cut with a hammer and punch, workmen usually mix some tow with the cement, the fibres of which hold its parts together.

CEMENT FOR BUILDING. See MORTAR CEMENTS.

CEMENTATION. A chemical process, which consists in surrounding a body in the solid state with the powder of some other bodies, and exposing the whole for a time in a closed vessel, to a degree of heat not sufficient to fuse the contents.

CERASIN is a name given to those gummy substances which readily swell in water without dissolving.

CERATE is a mixture of oil or lard with wax, used by surgeons to protect ulcerated sores from the air.

CERIN is a term which has been applied to various substances. 1. If cork be digested in alcohol, and the liquid be evaporated, a substance will precipitate in small white needles, and this has been named cerin. 2. That part of bees' wax which is soluble in alcohol, is called cerin. 3. A variety of the mineral called allanite: it consists, according to Berzelius, of oxide of cerium 28.19, oxide of iron 20.72, oxide of copper 0.87, silica 30.7, alumina 11.31, lime 9.12, volatile water 0.40.

CERITE is a rare mineral, of a rose red or flesh red colour, occasionally tinged with brown. Klaproth found 54.5 oxide of cerium, and 34.5 silica, in the 100 parts. Others have given a different result. Specific gravity from 4.6 to 4.9.

CERIUM is the metal obtained from cerite.

To obtain the oxide of the new metal, the cerite is calcined, pulverized, and dissolved in nitromuriatic acid. The filtered solution being neutralized with pure potash, is to be precipitated by tartrate of potash; and the precipitate, well washed, and afterwards calcined, is oxide of cerium.

Cerium is susceptible of two stages of oxidation: in the first it is white, and this by calcination becomes of a fallow red.

The white oxide exposed to the blow pipe soon becomes red, but does not melt, or even agglutinate. With a large proportion of borax it fuses into a transparent globule.

The white oxide becomes yellowish in the open air, but never so red as by calcination, because it absorbs carbonic acid, which prevents its saturating itself with oxygen, and retains a portion of water, which diminishes its colour.

Alkalis do not act on it; but caustic potash in the dry way takes part of the oxygen from the red oxide, so as to convert it into the white without altering its nature.

Equal parts of the sulphuric acid and red oxide, with four parts of water, unite by the assistance of heat into a crystaline mass; which may be completely dissolved by adding more acid, and heating them together a long time. This solution yields, by gentle evaporation, small crystals, some of an orange, others of a lemon colour. The sulphate of cerium is soluble in water only with an excess of acid. Its taste is acid and saccharine. The sulphuric acid combines readily with the white oxide, particularly in the state of carbonate. The solution has a saccharine taste, and readily affords white crystals.

Nitric acid does not readily dissolve the red oxide without heat. With an excess of acid, white deliquescent crystals are formed, which are decomposable by heat. Their taste is at first pungent, afterward very sugary. The white oxide unites more readily with the acid.

Muriatic acid dissolves the red oxide with effervescence. The solution crystallizes confusedly. The salt is deliquescent, soluble in an equal weight of cold water, and in three or four times its weight of alcohol. The flame of this solution, if concentrated, is yellow and sparkling; if not, colourless; but on agitation it emits white, red, and purple sparks.

Carbonic acid readily unites with the oxide. This is best done by adding carbonate of potash to the nitric and muriatic solution of the white oxide, when a light precipitate will be thrown down, which on drying assumes a shining silvery appearance, and consists of 23 acid + 65 oxide + 12 water.

The white oxide unites directly with tartaric acid, but requires an excess to render it soluble.

CERUMEN is a yellow coloured secretion which lines the internal auditory canal, and which is rendered viscid and concrete by exposure to the air. It consists of albumen, and inspissated oil, a colouring matter, soda, and calcareous phosphate.

CERUSE, OR WHITE LEAD, is lead oxidized by exposure to the air, heat, and acetic acid.

CETINE is a name given to spermaceti. It consists, according to Berard, of 81 carbon, 6 oxygen, and 13 hydrogen, in 100 parts.

CEYLANITE is a mineral found in Ceylon, of an indigo blue colour, commonly in round pieces, but not unfrequently in crystals of an octohedron form, or with the edges truncated. It has little external lustre but is splendid internally.

CHABASITE is a mineral consisting of 43.33 silica, 22.66 alumina, 3.34 lime, 9.34 soda, and 21 water.

CHALK. A very common species of calcareous earth, of an opaque white colour, very soft, and without the least appearance of a polish in its fracture. Its specific gravity is from 2.4 to 2.6, according to Kirwan. It contains a little silicious earth, and about two per cent. of clay. Some specimens, and perhaps most, contain a little iron, and Bergman affirms that muriate of lime, or magnesia, is often found in it; for which reason he directs the powder of chalk to be several times boiled in distilled water, before it is dissolved for the purpose of obtaining pure calcareous earth.

Chalk is a very soft white calcareous stone, too well known to need a particular description. Chalk occupies situations near the sea, and has a low comparative elevation. Chalk is common in the south-eastern part of England, and in the lower districts of Europe, at no great distance from the Baltic and the German ocean; but it is believed that no calcareous stone exactly similar is found in the south of Europe, or in Asia or Africa, though some earthy limestones have been called chalk by travellers. Neither chalk nor roestone was discovered by Humboldt in South America, nor have they been observed in any part of the United States.

The chalk hills of England spread through many of the eastern counties from Dorsetshire to the hills called the Wolds in the east riding of Yorkshire. The upper or soft chalk containing flint is from 400 to 600 feet in thickness; in many parts of its course it lies in thick beds indistinctly stratified. Nodules of flint are arranged in chalk in parallel layers at different depths under each other.

CHALK (BLACK) is a mineral used in crayon drawing. It is in opaque, tabular fragments, and stains paper black. It is called drawing slate. Specific gravity 2.4. It occurs in primitive mountains, often accompanied with alum slate. It becomes red in the fire and falls to pieces in water.

CHALK (RED.) This is a clay coloured by the oxide of iron, of which it contains from 10 to 18 parts in the hundred, according to Rinman.

CHALK (SPANISH.) The soap rock is frequently distinguished by this name.

CHALK STONES. Concretions formed by the disease called the gout.

CHARACTERS (CHEMICAL.) The chemical characters were invented by the earlier chemists, probably to save time in writing the names of substances that frequently occurred, in the same manner as we avoid repetitions by the use of pronouns. The moderns consider them as relics of alchemistical obscurity, and have almost totally rejected their use. Very little of system appears in the ancient characters of chemists: the characters of Bergman are chiefly grounded on the ancient characters, with additions and improvements. But the characters of Hassenfratz and Adet are systematical throughout.

CHARCOAL. When vegetable substances are exposed to a strong heat in the apparatus for distillation, the fixed residue is called charcoal. For general purposes, wood is converted into charcoal by building it up in a pyramidal form, covering the pile with clay or earth, and leaving a few air-holes, which are closed as soon as the mass is well lighted; and by this means the combustion is carried on in an imperfect manner. In the forest of Benon, near Rochelle,

great attention is paid to the manufacture, so that the charcoal made there, fetches 25 or 30 per cent. more than any other. The wood is that of the black oak. It is taken from ten to fifteen years old, the trunk as well as the branches, cut into billets about four feet long, and not split. The largest pieces, however, seldom exceed six or seven inches in diameter. The end that rests on the ground is cut a little sloping, so as to touch it merely with an edge, and they are piled nearly upright, but never in more than one story. The wood is covered all over about four inches thick with dry grass or fern, before it is enclosed in the usual manner with clay; and when the wood is charred, half a barrel of water is thrown over the pile, and earth to the thickness of five or six inches is thrown on, after which it is left four-and-twenty hours to cool. The wood is always used in the year in which it is cut.

In charring wood it has been conjectured, that a portion of it is sometimes converted into a pyrophorus, and that the explosions that happen in powder-mills are sometimes owing to this.

When charcoal is to be used in the manufacture of gunpowder, it is of essential importance that it be entirely freed from the least portion of acetic acid and tar. The following table from the third volume of Tilloch's Magazine, will shew the result of very accurately performed experiments of Mr. Mushet. It is to be observed, however, that when charcoal is made on a large scale, much will depend on the skill of the workmen in conducting the operation, and accordingly burning charcoal is a trade.

Parts in 100.

	Volatile Matter.	Charcoal.	Ashes	Charcoal by Proust.	Charcoal by Rumford.
Oak	76.895	22.682	0.423	20.	43.00
Ash	81.260	17.972	0.768	17.	
Birch	80.717	17.491	1.792		
Norway Pine	80.441	19.204	0.355	20.	44.18
				Black Ash.	
Mahogany	73.528	25.492	0.980	25.	
Sycamore	79.20	19.734	1.066		
				Willow.	
Holly	78.92	19.918	1.162	17.	
				Heart of Oak.	
Scotch Pine	83.095	16.456	0.419	19.	
Beech	79.104	19.941	0.955		
Elm	79.655	19.574	0.761		43.27
Walnut	78.521	20.663	0.81		
American Maple	79.331	19.901	0.768		42.23
				Guiacum.	
Do Black Beech,	77.512	21.445	1.033	24.	
Laburnum	74.234	24.586	1.180		
					Poplar.
Lignum Vitæ	72.643	26.857	0.500		43.57
Sallow	80.371	18.497	1.132		
					Lime.
Chesnut	76.304	23.280	0.416		43.59

Charcoal is black, sonorous, and brittle, and in general retains the figure of the vegetable it was obtained from. If, however, the vegetable consist for the most part of water or other fluids, these in their extrication will destroy the connection of the more fixed parts. In this case the quantity of charcoal is much less than in the former. The charcoal of oily or bituminous substances is of a light pulverulent form, and rises in soot. This charcoal of oils is called lamp black. A very fine kind is obtained from burning alcohol.

Turf or peat has been charred lately in France, it is said, by a peculiar process, and, according to the account given in Sonnini's Journal, is superior to wood for this purpose. Charcoal of turf kindles slower than that of wood, but emits more flame, and burns longer. In a goldsmith's furnace it fused eleven ounces of gold in eight minutes, while wood charcoal required sixteen. The malleability of the gold, too, was preserved in the former instance, but not in the latter. Iron heated red-hot by it in a forge was rendered more malleable.

From the scarcity of wood in this country, pit-coal charred, is much used instead of charcoal, by the name of Coke.

CHAY, OR CHAYA-ROOT. This is the root of the *Oldenlandia umbellata*, which grows wild on the coast of Coromandel, and is likewise cultivated there for the use of the dyers and calico printers. It is used for the same purposes as madder with us, to which it is said to be far superior, giving the beautiful red so much admired in the Madras cottons.

CHEESE. Milk consists of butter, cheese, a saccharine matter called sugar of milk, and a small quantity of common salt, together with much water.

If any vegetable or mineral acid be mixed with milk, the cheese separates, and, if assisted by heat, coagulates into a mass. The quantity of cheese is less when a mineral acid is used. Neutral salts, and likewise all earthy and metallic salts, separate the cheese from the whey. Sugar and gum arabic produce the same effect. Caustic alkalis will dissolve the curd by the assistance of a boiling heat, and acids occasion a precipitation again. Vegetable acids have very little solvent power upon curd. This accounts for a greater quantity of curd being obtained when a vegetable acid is used. But what answers best is rennet, which is made by macerating in water a piece of the last stomach of a calf, salted and dried for this purpose.

Scheele observed, that cheese has a considerable analogy to albumen, which it resembles in being coagulable by fire and acids, soluble in ammonia, and affording the same products by distillation or treatment with nitric acid. There are, however, certain differences between them. Rouelle observed likewise, a striking analogy between cheese and the gluten of wheat, and that found in the feculæ of green vegetables. By kneading the gluten of wheat with a little salt and a small portion of a solution of starch, he gave it the taste, smell, and unctuosity of cheese, so that after it had been kept a certain time, it was not to be distinguished from the celebrated Rochefort cheese, of which it had all the pungency. This caseous substance from gluten, as well as the cheese of milk, appears to contain acetate of ammonia, after it has been kept long enough to have undergone the requisite fermentation, as may be proved by examining it with sulphuric acid, and with potash. The pungency of strong cheese, too, is destroyed by alcohol.

In the 11th volume of Tilloch's Magazine there is an excellent account of the mode of making Cheshire cheese, taken from the Agricultural Report of the county. "If the milk," says the reporter, "be set together very warm, the curd, as before observed, will be firm; in this case, the usual mode is to take a common case knife, and make incisions across it, to the full depth of the knife's blade, at the distance of about one inch; and again crossways in the same manner, the incisions intersecting each other at right angles. The whey rising through these incisions is of a fine pale green colour. The cheese-maker and two assistants then proceed to break the curd; this is performed by their repeatedly putting their hands down into the tub; the cheese-maker, with the skimming dish in one hand, breaking every part of it as they catch it, raising the curd from the bottom, and still breaking it. This part of the business is continued till the whole is broken uniformly small; it generally takes up

about 40 minutes, and the curd is then left covered over with a cloth for about half an hour to subside. If the milk has been set cool together, the curd, as before mentioned, will be much more tender, the whey will not be so green, but rather of a milky appearance."

CHEMISTRY is the art and science, the object of which is to ascertain what are the component parts of all substances, and what effects are produced on them by change of temperature, or by their mutual action upon each other; and the mode and laws by which these changes are effected.

CHENOPODIUM OLIDUM is a plant exhaling a remarkably nauseous odour, strongly resembling that of putrid fish. When the plant is bruised, and the water expressed and distilled, a fluid is obtained which contains the subcarbonate of ammonia, and an oily matter which gives it a milky appearance. From 100 parts of the dried plant are produced 18 of ashes, of which 5½ are potash.

CHERT or CHIRK, is the name given by the miners to a silicious slate, which is massive, not disposed to pass into thin layers, but occurring in thick beds. Colour blueish, passing into yellowish grey. Fracture splintery; edges translucent. Specific gravity 2.6364. Blocks of it are used in the porcelain manufactories, in the midland counties, for grinding flint stones for the finer porcelain, and the purity of the rock augments the product of fine silicious earth by its own attrition during the process. There is another sort called by the miners White Chert, which seems to be a transition of silicious slate into quartz. It is not only used for grinding flints, but also as common millstone. A variety of chert has been found to answer as well as the best buhr stones of France in flour mills, and are manufactured for that purpose. They may be had from 50 lb. to several hundred weight each. See Hornstone.

CHIASTOLITE, a mineral distinguished from steatite by being crystallized.

CHLORATES are compounds of the chloric acid with earths, alkalis, and metals.

CHLORIODIC ACID. This acid was formed by Sir H. Davy, by admitting chlorine in excess to iodine, which absorbs less than one third of its weight of chlorine.

CHLORINE. The introduction of this term, originated from the masterly researches of Sir H. Davy on the oxymuriatic acid gas of the French school, which, after resisting the most powerful means of decomposition which his sagacity could invent, he declared to be an elementary body, and not a compound of muriatic acid and oxygen, as was previously imagined. He accordingly assigned to it the term chlorine, descriptive of its colour.

"In the Bakerian lecture for 1808," says he, "I have given an account of the action of potassium upon muriatic acid gas, by which more than one third of its volume of hydrogen is produced; and I have stated, that muriatic acid can in no instance be procured from oxymuriatic acid, or from dry muriates, unless water or its elements be present.

"In the second volume of the Memoires D'Arcueil, MM. Gay Lussac and Thenard have detailed an extensive series of facts, upon muriatic acid, and oxymuriatic acid. Some of their experiments are similar to those I have detailed in the paper just referred to; others are peculiarly their own, and of a very curious kind; their general conclusion is, that muriatic acid gas contains about one quarter of its weight of water; and that oxymuriatic acid is not decomposable by any substances but hydrogen, or such as can form triple combinations with it.

"One of the most singular facts that I have observed on this subject, and which I have before referred to, is that charcoal, even when ignited to whiteness in oxymuriatic or muriatic acid gases, by the voltaic battery, effects no change in them, if it has been previously freed from hydrogen and moisture, by intense ignition *in vacuo*.

"This experiment, which I have

several times repeated, led me to doubt of the existence of oxygen in that substance, which has been supposed to contain it, above all others, in a loose and active state; and to make a more rigorous investigation, than had hitherto been attempted for its detection."

His views were slowly and reluctantly admitted by the chemical philosophers of Europe. The hypothesis of Lavoisier, that combustion was merely the combination of oxygen with a basis, had become a favourite idol with the learned

Sir H. Davy subjected oxymuriatic gas to the action of many simple combustibles, as well as metals, and from the compounds formed, endeavoured to eliminate oxygen, by the most energetic powers of affinity and voltaic electricity, but without success.

It has been said, and taken for granted by many chemists, that when oxymuriatic acid and ammonia act upon each other, water is formed.

Few substances, perhaps, have less claim to be considered as acid, than oxymuriatic acid. As yet we have no right to say that it has been decompounded; and as its tendency of combination is with pure inflammable matters, it may possibly belong to the same class of bodies as oxygen.

May it not in fact be a *peculiar* acidifying and dissolving principle, forming compounds with combustible bodies, analogous to acids containing oxygen or oxides, in their properties and powers of combination; but differing from them, in being for the most part decomposable by water? On this idea muriatic acid may be considered as having hydrogen for its basis, and oxymuriatic acid for its acidifying principle. And the phosphoric sublimate as having phosphorus for its basis, and oxymuriatic acid for its acidifying matter. And Libavius's liquor, and the compounds of arsenic with oxymuriatic acid, may be regarded as analogous bodies. The combinations of oxymuriatic acid with lead, silver, mercury, potassium, and sodium, in this view, would be considered as a class of bodies related more to oxides than acids, in their powers of attraction.—*Bak. Lec.* 1809.

Oxymuriatic gas combines with inflammable bodies, to form simple binary compounds; and in these cases, when it acts upon oxides, it either produces the expulsion of their oxygen, or causes it to enter into new combinations.

Contrary to acids, it expels oxygen from prot-oxides, and combines with peroxides.

When potassium is burnt in oxymuriatic gas, a dry compound is obtained. If potassium combined with oxygen is employed, the whole of the oxygen is expelled, and the same compound formed.

It is generally stated in chemical books, that oxymuriatic gas is capable of being condensed and crystallized at a low temperature. He found by several experiments that this is not the case.

Potassium, sodium, calcium, strontium, barium, zinc, mercury, tin, lead, and probably silver, antimony, and gold, seem to have a stronger attraction for oxymuriatic gas than for oxygen.

To call a body which is not known to contain oxygen, and which cannot contain muriatic acid, oxymuriatic acid, is contrary to the principles of that nomenclature in which it is adopted; and an alteration of it seems necessary to assist the progress of discussion, and to diffuse just ideas on the subject. If the great discoverer of this substance had signified it by any simple name, it would have been proper to have recurred to it; but dephlogisticated marine acid is a term which can hardly be adopted in the present advanced era of the science.

After consulting some of the most eminent chemical philosophers in this country, it has been judged most proper to suggest a name founded upon one of its obvious and characteristic properties—its colour, and to call it *chlorine*, or *chloric* gas.

Should it hereafter be discovered to be compound, and even to contain oxygen, this name can imply

no error, and cannot necessarily require a change.

Most of the salts which have been called muriates, are not known to contain any muriatic acid, or any oxygen. Thus Libavius's liquor, though converted into a muriate by water, contains only tin and oxymuriatic gas, and horn-silver seems incapable of being converted into a true muriate."—*Bak. Lec.* 1811.

We shall now exhibit a summary view of the preparation and properties of chlorine.

Mix in a mortar three parts of common salt and one of black oxide of manganese. Introduce them into a glass retort, and add two parts of sulphuric acid. Gas will issue, which must be collected in the water-pneumatic trough.

This gas is of a greenish-yellow colour, easily recognised by daylight, but scarcely distinguishable by that of candles. Its odour and taste are disagreeable, strong, and so characteristic, that it is impossible to mistake it for any other gas.

Its specific gravity is 2.4733.

In its perfectly dry state, it has no effect on dry vegetable colours. With the aid of a little moisture, it bleaches them into a yellowish-white. Scheele first remarked this property; Berthollet applied it to the art of bleaching in France, and from him Mr. Watt introduced it into Great Britain.

If a lighted wax taper be immersed rapidly into this gas, it consumes very fast, with a dull reddish flame, and much smoke. The taper will not burn at the surface of the gas.

Its taste is somewhat astringent, but not in the least degree acidulous.

When we put in a perfectly dark place, at the ordinary temperature, a mixture of chlorine and hydrogen, it experiences no kind of alteration, even in a great many days. But if, at the same low temperature, we expose the mixture to the diffuse light of day, by degrees the two gases enter into chemical combination, and form muriatic acid gas.

CHLORITE is a mineral composed of a multitude of little spangles, or shining small grains, falling to powder under the pressure of the fingers. There are four sub-species. 1. *Chlorite earth.* In green, glimmering, and somewhat pearly scales, with a shining green streak. Specific gravity 2.6. It consists of 50 silica, 26 alumina, 1.5 lime, 5 oxide of iron, 17.5 potash. 2. *Common chlorite.* Specific gravity 2.83. Its constituents are 26 silica, 18.5 alumina, 8 magnesia, 43 oxide of iron, and 2 muriate of potash. 3. *Chlorite slate.* A massive, blackish green mineral, with resinous lustre, and curve slaty or scaly-foliated fracture. Feels somewhat greasy. Specific gravity 2.82. 4. *Foliated chlorite.* Its constituents are 35 silica, 18 alumina, 29.9 magnesia, 9.7 oxide of iron, 2.7 water.

CHLOROPHANE. A violet *fluor spar*, found in Siberia.

CHLORIDES. Compounds of chlorine with bases. See the respective bases.

CHLORO CARBONOUS ACID. The term chloro carbonic which has been given to this compound is incorrect, leading to the belief of its being a compound of chlorine and acidified charcoal, instead of being a compound of chlorine and the protoxide of charcoal. They combine when exposed to the direct solar beams, and one volume of each is condensed into one volume of the compound. The resulting gas possesses properties, approaching to those of an acid.

It does not fume in the atmosphere. Its odour is different from that of chlorine.

It reddens dry litmus paper; and condenses four volumes of ammonia into a white salt, while heat is evolved. Sulphuric acid resolves it into carbonic and muriatic acids, in the proportion of two in volume of the latter, and one of the former. Tin, zinc, antimony, and arsenic, heated in chloro-carbonous acid, abstract the chlorine, and leave the carbonic oxide expanded to its original volume.

From its completely neutralizing ammonia, and its reddening vegetable blues, there can be no

hesitation in pronouncing the chloro-carbonous compound to be an acid. Its saturating powers, indeed, surpass every other substance. None condenses so large a proportion of ammonia.

One measure of alcohol condenses twelve of chloro-carbonous gas without decomposing it; and acquires the peculiar odour and power of affecting the eyes.

CHLOROUS AND CHLORIC OXIDES, or the protoxide and deutoxide of chlorine.

Both of these interesting gaseous compounds were discovered by Sir H. Davy.

1st, The experiments which led him to the knowledge of the first, were instituted in consequence of the difference he had observed between the properties of chlorine, prepared in different modes.

Its tint is much more lively, and more yellow than chlorine, and hence its illustrious discoverer named it *euchlorine*.

This gas must be collected and examined with much prudence, and in very small quantities. A gentle heat, even that of the hand, will cause its explosion, with such force as to burst thin glass.

2nd, *Deutoxide of Chlorine*, or *Chloric Oxide*. "On Thursday the 4th May, a paper by Sir H. Davy was read at the Royal Society, on the action of acids on hyper-oxymuriate of potash. When sulphuric acid is poured upon this salt in a wine-glass, very little effervescence takes place, but the acid gradually acquires an orange colour, and a dense yellow vapour, of a peculiar and not disagreeable smell, floats on the surface. These phenomena led the author to believe, that the substance extricated from the salt is held in solution by the acid. After various unsuccessful attempts to obtain this substance in a separate state, he at last succeeded by the following method: About 60 grains of the salt are triturated with a little sulphuric acid, just sufficient to convert them into a very solid paste. This is put into a retort, which is heated by means of hot water. The water must never be allowed to become boiling hot, for fear of explosion. The heat drives off the new gas, which may be received over mercury. This new gas has a much more intense colour than euchlorine. It does not act on mercury. Water absorbs more of it than of euchlorine. Its taste is astringent. It destroys vegetable blues without reddening them. When phosphorus is introduced into it, an explosion takes place. When heat is applied, the gas explodes with more violence, and producing more light than euchlorine. When thus exploded, two measures of it are converted into nearly three measures, which consist of a mixture of one measure chlorine, and two measures oxygen. Hence, it is composed of one atom chlorine and four atoms oxygen."

Since two measures of this gas, at 212°, explode and form three measures of mingled gases, of which two are oxygen and one chlorine; its composition by weight is—

Oxygen,	2.2222,	4 primes,	4.00	47.33
Chlorine,	2.4733,	1 do.	4.45	52.67
			8.45	100.00

Its specific gravity is 2.3477; and hence 100 cubic inches of it weigh about 77 grains.

CHLOROPHILE. The name lately given by MM. Pelletier and Caventou to the green matter of the leaves of plants. They obtained it, by pressing and then washing in water, the substance of many leaves, and afterwards treating it with alcohol. A matter was dissolved, which, when separated by evaporation, and purified by washing in hot water, appeared as a deep green resinous substance. It dissolves entirely in alcohol, ether, oils, or alkalis; it is not altered by exposure to air; it is softened by heat, but does not melt; it burns with flame, and leaves a bulky coal. Hot water slightly dissolves it. Acetic acid is the only acid that dissolves it in great quantity. If an earthy or metallic salt be mixed with the alcoholic solution, and then alkali, or alkaline subcarbonate be added, the oxide or earth is thrown down in combination with much of the

green substance, forming a lake. These lakes appear moderately permanent when exposed to the air. It is supposed to be a peculiar proximate principle.

CHOLESTERINE. The name given by M. Chevreul to the pearly substance of human biliary calculi. It consists of 72 carbon, 6.66 oxygen, and 21.33 hydrogen, by Berard.

CHOLESTERIC ACID. By heating cholesterine with its own weight of strong nitric acid until it ceases to give off nitrous gas, MM. Pelletier and Caventou obtained a yellow substance, which separated on cooling, and was scarcely soluble in water. When well washed, this is cholesteric acid. It is soluble in alcohol, and may be crystallized by evaporation. It is decomposed by a heat above that of boiling water, and gives products having oxygen, hydrogen, and charcoal, for their elements. It combines with bases, and forms salts. Those of soda, potash, and ammonia, are very soluble; the rest are nearly insoluble.

CHROMIC ACID. This acid has been examined principally by Vauquelin, who first discovered it, and by Count Mussin Puschkin; yet we are better acquainted with it than with the metal that forms it basis. However, as the chromate of iron has lately been found in abundance in the department of Var, in France, and in some other places, we may expect its properties to be more amply investigated, and applied with advantage in the arts, as the chromates of lead and iron are of excellent use in painting and enamelling.

It was extracted from the red lead ore of Siberia, by treating this ore with carbonate of potash, and separating the alkali by means of a more powerful acid. In this state it is a red or orange-coloured powder, of a peculiar rough metallic taste, which is more sensible in it than in any other metallic acid. If this powder be exposed to the action of light and heat, it loses its acidity, and is converted into green oxide of chrome, giving out pure oxygen gas. The chromic acid is the first that has been found to de-oxygenate itself easily by the action of heat, and afford oxygen gas by this simple operation. It appears that several of its properties are owing to the weak adhesion of a part at least of its oxygen. The green oxide of chrome cannot be brought back to the state of an acid, unless its oxygen be restored by treating it with some other acid.

The chromic acid is soluble in water, and crystallizes, by cooling and evaporation, in longish prisms of a ruby red. Its taste is acrid and styptic. Its specific gravity is not exactly known; but it always exceeds that of water. It powerfully reddens the tincture of turnsole.

Its action on combustible substances is little known. If it be strongly heated with charcoal, it grows black, and passes to the metallic state without melting.

Of the acids, the action of the muriatic on it is the most remarkable. If this be distilled with the chromic acid, by a gentle heat, it is readily converted into chlorine. It likewise imparts to it by mixture the property of dissolving gold; in which the chromic resembles the nitric acid. This is owing to the weak adhesion of its oxygen, and it is the only one of the metallic acids that possesses this property.

It readily unites with alkalis, and is the only acid that has the property of colouring its salts, whence the name of chromic has been given it. If two parts of the red lead ore of Siberia, in fine powder, be boiled with one of an alkali saturated with carbonic acid, in forty parts of water, a carbonate of lead will be precipitated, and the chromate remain dissolved. The solutions are of a lemon colour, and afford crystals of a somewhat deeper hue. Those of chromate of ammonia are in yellow laminæ, having the metallic lustre of gold.

The chromate of barytes is very little soluble, and that of lime still less. They are both of a pale yellow, and when heated give out oxygen gas, as do the alkaline chromates.

If the chromic acid be mixed with filings of tin and the muriatic acid, it becomes at first yellowish brown, and afterwards assumes a bluish green colour, which preserves the same shade after desiccation. Ether alone gives it the same dark colour. With a solution of nitrate of mercury it gives a precipitate, of a dark cinnabar colour. With a solution of nitrate of silver it gives a precipitate which, the moment it is formed, appears of a beautiful carmine colour, but becomes purple by exposure to the light. This combination, exposed to the heat of the blowpipe, melts before the charcoal is inflamed, and assumes a blackish and metallic appearance. If it be then pulverized, the powder is still purple; but after the blue flame of the lamp is brought into contact with this powder, it assumes a green colour, and the silver appears in globules disseminated through its substance.

With nitrate of copper it gives a chesnut-red precipitate. With the solution of sulphate of zinc, muriate of bismuth, muriate of antimony, nitrate of nickel, and muriate of platina, it produces yellowish precipitates, when the solutions do not contain an excess of acid. With muriate of gold it produces a greenish precipitate.

When melted with borax, or glass, or acid of phosphorus, it communicates to it a beautiful emerald green colour.

If paper be impregnated with it, and exposed to the sun a few days, it acquires a green colour, which remains permanent in the dark.

A slip of iron, or tin, put into its solution, imparts to it the same colour.

The aqueous solution of tannin produces a flocculent precipitate of a brown fawn colour.

Sulphuric acid, when cold, produces no effect on it; but when warm it makes it assume a bluish green colour.

If the chromic oxide be heated with a solution of alkali in water, it will become chromic acid, which is of a yellow colour. If the chromic acid be heated with sulphuric or sulphurous acid, it will become an oxide of chromium which is of a green colour.

CHROMIUM is a very rare metal, and is found either in the form of chromate of lead, or of chromate of iron. It is found in combination with iron, also with alumina and silex, in the department of Var, in France. The emerald of Peru and spinel ruby owe their colours to this metal.

Chromium is obtained from its native combinations by decomposing them by the alkaline carbonates, precipitating the chromic acid, and heating it strongly in a crucible.

Chromium is a porous mass of aglutinate grains, brittle, of a white between tin and steel. Specific gravity 5.9. It is susceptible of a small degree of magnetism. It resists all the acids except the nitro muriatic.

The protoxide of chromium is green, infusible, indecomposable by heat, reducible by voltaic battery. It is obtained by calcining the chromate of mercury in an earthen retort. The deutoxide may be obtained by exposing the protonitrate to heat till the fumes of the nitrous cease to issue.

CHRYSOBERYL is the same mineral which is called Cymophane by Hauy. It is usually in round pieces about the size of a pea, but is also found in eight-sided prisms. Its colour is green, it is semi-transparent and hard, scratches quartz. It consists, according to Klaproth, of 71 alumina, 18 silica, 6 lime, 1½ oxide of iron. The summits of the prisms are sometimes so cut that the solid acquires 28 faces. This is a different mineral from the chrysoberyl of Pliny.

CHRYSOCOLLA, a Greek name for borax.

CHRYSOLITE, is the peridit of Hauy, the topaz of the ancients. It is a very soft gem, and may be scratched by quartz or by the file. The colour is of various shades of green. It is transparent. Specific gravity 3.4. It consists of 39 silica, 43.5 magnesia, and 19 oxide of iron, according to Klaproth. It is found in alluvial strata in Egypt.

CHRYSOPRASE is a variety of calcedony, hitherto found only at

Kosemütz, in Upper Silesia. It is found in veins or interrupted beds, in the midst of a green earth, which contains nickel. It is used in jewellery. It consists of 96 silica in the 100.

CHUSITE, a mineral of a yellowish colour, which dissolves without effervescence in acids, found by Saussure in the cavities of porphyries at Limbourg.

CHYLE AND CHYME. When food has been received into the stomachs of animals, by the action of the saliva and a juice in the stomach called the gastric juice, it is converted into a milky fluid called chyme. This fluid afterwards passes into the intestines where it unites with the pancreatic juice and bile, and is there separated into chyle, or into feculent matter which is carried on and discharged.

Chyle is taken up by the lacteal absorbent vessels, and finds its way into the blood, which is circulated over the whole system and supplies its constant waste.

CIMOLITE, OR CIMOLIAN EARTH. The *cimolia* of Pliny, which was used both medicinally and for cleaning cloths by the ancients, and which has been confounded with fullers' earth and tobacco-pipe clay, has lately been brought from Argentiera, the ancient Cimolus, by Mr Hawkins, and examined by Klaproth.

It is of a light greyish white colour, acquiring superficially a reddish tint by exposure to the air; massive; of an earthy, uneven, more or less slaty fracture; opaque; when shaved with a knife, smooth and of a greasy lustre; tenacious, so as not without difficulty to be powdered or broken, and adhering pretty firmly to the tongue. Its specific gravity is 2. It is immediately penetrated by water, and developes itself into thin laminæ of a curved slaty form. Triturated with water it forms a pappy mass; and 100 grains will give three ounces of water the appearance and consistence of a thickish cream. If left to dry after being thus ground, it detaches itself in hard bands, somewhat flexible, and still more difficult to pulverise than before.

It appeared on analysis to consist of silex 63, alumina 23, oxide of iron 1.25, water 12.

Ground with water, and applied to silk and woollen, greased with oil of almonds, the oil was completely discharged by a slight washing in water, after the stuffs had been hung up a day to dry, without the least injury to the beauty of the colour. Mr. Klaproth considers it as superior to our best fullers' earth; and attributes its properties to the minutely divided state of the silex, and its intimate combination with the alumina. It is still used by the natives of Argentiera for the same purposes as of old.

According to Olivier the island of Argentiera is entirely volcanic, and the cimolian earth is produced by a slow and gradual decomposition of the porphyries, occasioned by subterranean fires. He adds, that he collected specimens of it in all the states through which it passes.

CINCHONA. This is the plant which yields the bark which has been found of such utility in medicine, in the cure of fevers and strengthening of the constitution. It was first brought into use in Europe by the Jesuits, and it has accordingly been called Jesuits Bark. There are three varieties, the red, the yellow, and the pale. The red is easily pulverized, and yields a red brown powder having a bitter astringent taste. It contains resin, extractive matter, bitter principle, with some muriate of ammonia and lime, and tannin. It has also a portion of citric acid in it, by which its infusion will turn vegetable blue to red. The yellow bark is nearly the same as the red, except that it has a small portion of kinate of lime. The pale cinchona is that which is chiefly used in medicine. Bark is frequently adulterated by the mixture of the bark of willows and of other trees; and in consequence of this, there is often a failure of the benefit expected by the use of this medicine.

CINCHONIN, a peculiar resinous substance, which appears to be the same in all kinds of cin-

chona. It is very bitter, soluble in alcohol, and in acids and alkalis; very little soluble in cold water, but more abundantly in warm water. It is supposed that the febrifuge quality of bark depends chiefly on this substance.

CINNABAR, an ore of mercury, consisting of that metal and sulphur. This ore is the most common of the mercurial ores. It is of a red colour. It is found in veins, and is sometimes crystallized in three-sided pyramids.

CINNAMON STONE, a very rare mineral, found in the sand of rivers in Ceylon. It is of a blood red colour passing into orange yellow.

CIPOLIN. The cipolin from Rome is a green marble with white zones: it gives fire with steel, though difficultly. One hundred parts of it contains 67.8 of carbonate of lime; 25 of quartz; 8 of schistus; 0.2 of iron, beside the iron contained in the schistus. The cipolin from Autun contains 83 parts carbonate of lime, 12 of green mica, and one of iron.

CISTIC OXIDE, a kind of urinary calculus.

CITRIC ACID. The juice of lemons, or limes, has all the characters of an acid of considerable strength; but on account of the mucilaginous matter with which it is mixed it is very soon altered by spontaneous decomposition. Various methods have been contrived to prevent this effect from taking place, in order that this wholesome and agreeable acid might be preserved for use in long voyages, or other domestic occasions. The juice may be kept in bottles under a thin stratum of oil, which indeed prevents, or greatly retards, its total decomposition; though the original fresh taste soon gives place to one which is much less grateful. In the East Indies it is evaporated to the consistence of a thick extract. If this operation be carefully performed by a very gentle heat, it is found to be very effectual. When the juice is thus heated, the mucilage thickens, and separates in the form of flocks, part of which subsides, and part rises to the surface: these must be taken out. The vapours which arise are not acid. If the evaporation be not carried so far as to deprive the liquid of its fluidity, it may be long preserved in well closed bottles; in which, after some weeks' standing, a farther portion of mucilage is separated, without any perceptible change in the acid.

Of all the methods of preserving lemon juice, that of concentrating it by frost appears to be the best, though in the warmer climates it cannot conveniently be practised. Lemon-juice, exposed to the air, in a temperature between 50° and 60°, deposits in a few hours a white semitransparent mucilaginous matter, which leaves the fluid, after decantation and filtration, much less alterable than before. This mucilage is not of a gummy nature, but resembles the gluten of wheat in its properties: it is not soluble in water when dried. More mucilage is separated from lemon-juice by standing in closed vessels. If this depurated lemon-juice be exposed to a degree of cold of about seven or eight degrees below the freezing point, the aqueous part will freeze, and the ice may be taken away as it forms; and if the process be continued until the ice begins to exhibit signs of acidity, the remaining acid will be found to be reduced to about one-eighth of its original quantity, at the same time that its acidity will be eight times as intense, as is proved by its requiring eight times the quantity of alkali to saturate an equal portion of it. This concentrated acid may be kept for use, or, if preferred, it may be made into a dry lemonade, by adding six times its weight of fine loaf sugar in powder.

The above processes may be used when the acid of lemon is wanted for domestic purposes, because they leave it in possession of the oils, or other principles, on which its flavour peculiarly depends; but in chemical researches, where the acid itself is required to be had in the utmost purity, a more elaborate process must be used. Boiling lemon-juice is to be saturated with powdered chalk, the weight of which is to be noted, and the powder must be stirred up from

the bottom, or the vessel shaken from time to time.' The neutral saline compound is scarcely more soluble in water than selenite; it therefore falls to the bottom, while the mucilage remains suspended in the watery fluid, which must be decanted off; the remaining precipitate must then be washed with warm water until it comes off clear. To the powder thus edulcorated, a quantity of sulphuric acid, equal the chalk in weight, and diluted with ten parts of water, must be added, and the mixture boiled a few minutes. The sulphuric acid combines with the earth, and forms sulphate of lime, which remains behind when the cool liquor is filtered, while the disengaged acid of lemons remains dissolved in the fluid. This last must be evaporated to the consistence of a thin syrup, which yields the pure citric acid in little needle-like crystals. It is necessary that the sulphuric acid should be rather in excess, because the presence of a small quantity of lime will prevent the crystallization. This excess is allowed for above.

M. Dize, a skilful apothecary in Paris, who has repeated this process of Scheele on a very extensive scale, asserts, that an excess of sulphuric acid is necessary, not only to obtain the citric acid pure, but to destroy the whole of the mucilage, part of which would otherwise remain, and occasion its spoiling. It is not certain, however, but the sulphuric acid may act on the citric itself, and by decomposing it, produce the charcoal that M. Dize ascribes to the decomposition of mucilage; and if so, the smaller the excess of sulphuric acid the better. He also adds, that to have it perfectly pure it must be repeatedly crystallized, and thus it forms very large and accurately defined crystals in rhomboidal prisms, the sides of which are inclined in angles of 60° and 120°, terminated at each end by tetraedral summits, which intercept the solid angles. These, however, will not be obtained when operating on small quantities.

Its taste is extremely sharp, so as to appear caustic. Distilled in a retort, part rises without being decomposed; it appears to give out a portion of vinegar; it then evolves carbonic acid gas, and a little carburetted hydrogen; and a light coal remains. It is among the vegetable acids the one which most powerfully resists tion by fire.

In a dry and warm air it seems to effloresce; but it absorbs moisture when the air is damp, and at length loses its crystalline form. A hundred parts of this acid are soluble in seventy-five of water at 60°, according to Vauquelin. Though it is less alterable than most other solutions of vegetable acids it will undergo decomposition when long kept. Fourcroy thinks it probable that it is converted into acetic acid before its final decomposition.

It is not altered by any combustible substance; charcoal alone appears to be capable of whitening it. The most powerful acids decompose it less easily than they do other vegetable acids; but the sulphuric evidently converts it into acetic acid. The nitric acid likewise, according to Fourcroy and Vauquelin, if employed in a large quantity, and heated on it a long time, converts the greater part of it into acetic acid, and a small portion into oxalic. Scheele indeed could not effect this; but Westrumb supposes, that it was owing to his having used too much nitric acid; for on treating 60 grains of citric acid with 200 of nitric he obtained 30 grains of oxalic acid; with 300 grains of nitric acid he got 15; and with 600 grains no vestige of oxalic acid appeared.

If a solution of barytes be added gradually to a solution of citric acid, a flocculent precipitate is formed, soluble by agitation, till the whole of the acid is saturated. This salt at first falls down in powder, and then collects in silky tufts, and a kind of very beautiful and shining silvery bushes. It requires a large quantity of water to dissolve it.

The citrate of lime has been mentioned already, in treating of the mode of purifying the acid.

The citrate of potash is very soluble and deliquescent.

The citrate of soda has a dull saline taste; dissolves in less than twice its weight of water; crystallizes in six-sided prisms with flat summits; effloresces slightly, but does not fall to powder; boils up, swells, and is reduced to a coal on the fire. Lime-water decomposes it, but does not render the solution turbid, notwithstanding the little solubility of citrate of lime.

Citrate of ammonia is very soluble; does not crystallize unless its solution be greatly concentrated; and forms elongated prisms.

Citrate of magnesia does not crystallize. When its solution had been boiled down, and it had stood some days, on being slightly shaken it fixed in one white opaque mass, which remained soft, separating from the sides of the vessel, contracting its dimensions, and rising in the middle like a kind of mushroom.

Its combination with the other earths has not been much examined; and its action upon metals has been little studied. Scheele however found, that it did not precipitate the nitric solutions of metals, as the malic acid does.

All the citrates are decomposed by the powerful acids, which do not form a precipitate with them, as with the oxalates and tartrates. The oxalic and tartaric acids decompose them, and form crystallized or insoluble precipitates in their solutions. All afford traces of acetic acid, or a product of the same nature, on being exposed to distillation: this character exists particularly in the metallic citrates. Placed on burning coals they melt, swell up, emit an empyreumatic smell of acetic acid, and leave a light coal. All of them, if dissolved in water, and left to stand for a undergo decomposition, deposit a flocculent mucus which grows black, and leave their bases combined with carbonic acid, one of the products of the decomposition. Before they are completely decomposed, they appear to pass to the state of acetates.

The affinities of the citric acid are arranged by Vauquelin in the following order: barytes, lime, potash, soda, strontian, magnesia, ammonia, alumina. Those for zircone, glucine, and the metallic oxides, are not ascertained.

Citric acid has been found unmixed, with other acids, not only in lemons, oranges, and limes, but also in the berries of *vaccinium oxycoccos*, or cranberry, *vaccinium vitis idaea*, or red-whortleberry, of birdcherry, nightshade, hip, in unripe grapes and tamarinds. Gooseberries, currants, bilberries, beamberries, cherries, strawberries, cloudberries, and raspberries, contain citric acid mixed with an equal quantity of malic acid. The onion yields citrate of lime.

In order to discover if the citric acid has been adulterated with tartaric acid, add to the solution, very slowly, a solution of subcarbonate of potash, and there will be a white pulverulent precipitate of tartar.

When the citric acid is to be used instead of lemon juice, it is to be dissolved in twenty times its weight of water. It is an antidote against sea scurvy, but the fruit of the lemon is preferable, probably arising from the mucilage and other vegetable matter combined with it.

CIVET is collected betwixt the anus and the organs of generation of a fierce carnivorous quadruped met with in China and the East and West Indies, called a civet cat, but bearing a greater resemblance to a fox or marten than a cat.

Several of these animals have been brought into Holland, and afford a considerable branch of commerce, particularly at Amsterdam. The civet is squeezed out, in summer every other day, in winter twice a week: the quantity procured at once is from two scruples to a drachm or more. The juice thus collected is much purer and finer than that which the animal sheds against shrubs or stones in its native climates.

Good civet is of a clear yellowish or brownish colour, not fluid, nor hard, but about the consistence of butter or honey, and uniform throughout; of a very strong smell; quite offensive when undiluted; but agreeable when only a small

portion of civet is mixed with a large one of other substances.

Civet unites with oils, but not with alcohol. Its nature is therefore not resinous.

CLARIFICATION is the process of freeing a fluid from heterogeneous matter or feculences, though the term is seldom applied to the mere mechanical process of straining, for which see FILTRATION.

Albumen, gelatine, acids, certain salts, lime, blood, and alcohol, in many cases serve to clarify fluids, that cannot be freed from their impurities by simple percolation.

Albumen or gelatine, dissolved in a small portion of water, is commonly used for fining vinous liquors, as it inviscates the feculent matter, and gradually subsides with it to the bottom. Albumen is particularly used for fluids, with which it will combine when cold, as syrups; it being coagulated by the heat, and then rising in a scum with the dregs.

CLAY (PURE.) See ALUMINA.

CLAY. The clays being extensively distributed in nature, and used in many arts, deserve particular attention. They are all sufficiently soft to be scratched by iron; have a dull or even earthy fracture; exhale, when breathed on, a peculiar smell called argillaceous. The clays form with water a plastic paste, possessing considerable tenacity, which hardens with heat, so as to strike fire with steel. The affinity of the clays for moisture is manifested by their sticking to the tongue, and by the intense heat necessary to make them perfectly dry. The odour ascribed to clays breathed upon, is due to the oxide of iron mixed with them. Absolutely pure clays emit no smell.

1. *Porcelain earth*, the kaolin of the Chinese.—This mineral when pure, forms with difficulty a paste with water. It is infusible in a porcelain furnace. It is of a pure white, verging sometimes upon yellow or flesh red. It scarcely adheres to the tongue. Specific gravity 2.2. Kaolins are sometimes preceded by beds of a micaceous rock of the texture of gneiss, but red and very friable. The constituents of kaolin are 52 silica, 47 alumina, 0.33 oxide of iron; but some contain a notable proportion of water in their recent state. The Chinese and Japanese kaolins are whiter and more unctuous to the touch than those of Europe. The Saxon has a slight tint of yellow or carnation, which disappears in the fire, and therefore is not owing to metallic impregnation.

2. *Potters' clay, or plastic clay*, is compact, smooth, and almost unctuous to the touch, and may be polished by the finger when dry. It has a great affinity for water, forms a tenacious paste, and adheres strongly to the tongue. It acquires great solidity, but is infusible in the porcelain furnace. This property distinguishes it from common clays employed for coarse earthen ware. Specific gravity 2. Vauquelin's analysis of the plastic clay of Forges-les-Eaux, employed for making glasshouse pots, as well as pottery, gave 16 alumina, 63 silica, 1 lime, 8 iron, and 10 water. Another potters' clay gave 33.2 and 43.5 of alumina and silica, with 3.5 lime.

3. *Loam* is an impure potters' clay mixed with mica and iron ochre. Colour yellowish-grey, often spotted yellow and brown. Adheres pretty strongly to the tongue, and feels slightly greasy. Its density is inferior to the preceding.

4. *Variegated clay*.—Is striped or spotted with white, red, or yellow colours.

5. *Slate clay*.—Colour grey, or greyish yellow. Massive. Dull or glimmering lustre, from interspersed mica. Slaty fracture, approaching sometimes to earthy. Fragments tabular. Specific gravity 2.6.

6. *Claystone*.—Colour grey, of various shades, sometimes red, and spotted or striped.

7. *Adhesive slate*.—Colour light greenish-grey. Internal lustre dull; fracture in the large, slaty; in the small, fine earthy. Fragments slaty. Opaque. Shining streak. Sectile. Easily broken or exfoliated. Klaproth's analysis is 62.5 silica, 8 magnesia, 0.5 alumina, 0.25 lime, 4 oxide of iron, 22 water, and 0.75 charcoal. Its specific gravity is 2.08.

8. *Polishing slate* of Werner.—

Colour, cream yellow, in alternate stripes. It has been found only in Bohemia. Its constituents are 79 siliac, 1 alumina, 1 lime, 4 oxide of iron, and 14 water.

9. *Common clay* may be considered to be the same as *loam*.

CLAY-SLATE. Argillaceous schistus, the argillite of Kirwan. Colour, bluish-grey, and greyish-black of various shades. Massive. Opaque. Soft. Sectile. Easily broken. Sonorous, when struck with a hard body. Specific gravity 2.7. Its constituents are 48.6 silica, 23.5 alumina, 1.6 magnesia, 11.3 peroxide of iron, 0.5 oxide of manganese, 4.7 potash, 0.3 carbon, 0.1 sulphur, 7.6 water and volatile matter. Melts easily by the blow-pipe. This mineral is extensively distributed, forming a part of both primitive and transition mountains. The great beds of it are often cut across by thin seams of quartz or carbonate of lime, which divide them into rhomboidal masses. Good slates should not imbibe water. If they do, they soon decompose by the weather.

CLAY IRON STONE. An ore of iron.

CLINK STONE is a stone of an imperfect slaty structure, which rings like metal when struck with a hammer. It is brittle, hard as felspar, and translucent on the edges. Its constituents are 57.25 silica, 23.5 alumina, 2.75 lime, 8.1 soda, 3.25 oxide of iron, 0.25 oxide of manganese, and 3 of water.

CLINOMETER an instrument for measuring the depth of mineral strata.

CLOUDS. The vapours condensed by cold, or rising in the atmosphere to a region of air lighter than themselves, form visible mists, or strata of visible vapours, called clouds.

The clouds thus formed, occupy a peculiar region, elevated at an average about two miles above the earth. The mixture of different portions of air, most often occurs when the currents come in contact; which at a medium height, in reference also to the clouds, is about 15,000 feet. Most of the visible phenomena of the atmosphere arise from water, which, raised by evaporation, is transported from place to place in vapour, and is, physically speaking, a proper component of the air. When a portion of this is deprived of its heat, it re-appears in minute drops, at first uniformly diffused, lessening the transparency of the air in proportion to their abundance. There is usually a sufficient quantity of diffused water, towards evening, which is visible from above as a sea of *haze*. This is, in fact, the veil which, drawn over the sable of the sky, converts it to a blue of varied intensity; or, it shares with the transparent air in producing this effect. The next stage is *dew*; or *haze*, the appearance of dew while falling. Here the drops have become so collected as to form an aggregate faintly defined in the air. To this succeed the aggregate called *clouds*; whence are formed *rain*, *snow*, and *hail*, which finally restores the product of evaporation to the earth. The excess of the falling water over that evaporated, passes off by springs and rivers to those reservoirs which form the greater part of the earth's surface. Tracts of forest, especially if mountainous, invite the rain, and protect the springs; while the accumulated heat on cultivated plains, often causes the clouds passing over them to be dissipated. The atmosphere, at the height where clouds usually appear, flows in a more direct and even current, being undisturbed by the various obstacles which throw it into contending streams and eddies near the earth's surface. Accordingly, the particles of water it contains, assume a certain arrangement, and constitute a form, often equally well defined at a distance with that of solids, though, were we to penetrate it, we should perceive only a grey mist.

There are three simple and distinct modifications, in any one of which the aggregate of minute drops, called a cloud, may be formed, may then increase to the greatest extent, and finally decrease and disappear. The principal modifications are commonly as distinguishable from each other, as a tree from a hill, or the latter

from a lake; though clouds in the same modification, considered with respect to each other, have often only the common resemblances which exist among trees, hills, or lakes.

The simple modifications are thus named and defined:

1. *Cirrus.* Parallel, flexuous, or diverging fibres, extensible in any or every direction. 2. *Cumulus.* Convex or conical heaps, increasing upward from a horizontal base. 3. *Stratus.* A widely extended, continuous, horizontal sheet, increasing from below.

Besides these simple modifications, there are others which are compounded of them.

4. *Cirro-cumulus.* Small, well defined, roundish masses, in close horizontal arrangement. 5. *Cirro-stratus.* Horizontal or slightly inclined masses, attenuated towards a part or the whole of their circumference, concave downward; or undulated, separate, or in groups, consisting of small clouds, having these characters. 6. *Cumulo-stratus.* A dense cloud with the base of the cumulus, but in its upper part extended into a broad flat structure. 7. *Cumulo cirrus.* The rain cloud, or system of clouds, from which rain is fallen. It is a horizontal sheet, above which the cirrus spreads, while, the cumulus enters it laterally, and from beneath. *See the annexed Plate.*

The cirrus has the least density, the greatest elevation, and variety of extent and direction; it is the earliest appearance after serene weather, first indicated by a few threads pencilled in the air. These increase in length, and new ones are added laterally.

The process may be compared either to vegetation or to crystallization; but it is clearly analogous to the delicate arrangements which ensue in the particles of coloured powders, such as chalk, vermilion, &c. when these are projected on a cake of wax, after it has been touched with the knob of a charged Leyden phial. We may consider the particles of water as similarly placed upon or beneath a plate of charged air. Their duration is uncertain, varying from a few minutes after the first appearance to an extent of many hours. It is long when they appear alone, and at great heights; and shorter when they are formed lower, and in the vicinity of other clouds. In fair weather, with light variable breezes, the sky is seldom quite clear of small groups of the oblique cirrus, which frequently come on from leeward, and the direction of their increase is to windward. Continued wet weather is attended with horizontal sheets of this cloud, which subside quickly, and pass to the cirro-stratus.

The cumulus is commonly of the most dense structure. It is formed in the lower atmosphere, and moves along with the current which is next the earth. A small irregular spot first appears, and is as it were the nucleus on which they increase. The lower surface continues irregularly plane, while the upper rises into conical or hemispherical heaps.

Their appearance, increase, and disappearance, in fair weather, are often periodical, and keep pace with the temperature of the day. Thus they begin to form some hours after sunrise, arrive at their maximum in the hottest part of the afternoon, then go on diminishing, and totally disperse about sunset. The formation of large cumuli to leeward in a strong wind, indicates the approach of a calm with rain. When they do not disappear or subside about sunset, but continue to rise, thunder is to be expected in the night.

Independently of the beauty and magnificence it adds to the face of nature, the cumulus serves to screen the earth from the direct rays of the sun; by its multiplied reflections to diffuse, and, as it were, economize the light; and also to convey the product of evaporation to a distance from the place of its origin.

The stratus has a mean density; is the lowest of clouds, its lower surface commonly resting on the earth or water. It is properly the cloud of night; its first appearance being about sunset. It comprehends all those creeping mists which in calm evenings ascend

from the bottom of valleys, in spreading sheets, like an inundation of water.

The cirrus having increased for some time usually descends to a lower station in the atmosphere, and passes to the *cirro-cumulus*, or the cirro-stratus. The cirro-cumulus is formed from a cirrus, or from small separate cirri, by the fibres collapsing into small roundish masses, in which the texture of the cirrus is no longer discernible. This modification forms a very beautiful sky, sometimes exhibiting numerous distinct beds of these small connected clouds floating at different altitudes. The cirro-cumulus is a sure prognostic of increased temperature; is frequent in summer, and attendant on warm and dry weather. It is occasionally, but less frequently, seen in the intervals of showers, and in winter; it may either evaporate, or pass to the cirrus or cirro-stratus.

The cirro-stratus results from the fibres of the cirrus subsiding to a horizontal position, when they approach each other laterally. The form and relative position, seen in the distance, frequently give the idea of shoals of fish. The cirro-stratus precedes wind and rain, whose near or distant approach may be estimated from its abundance and permanence. It may mostly be seen in the intervals of storms. The cirro-stratus, most frequently and completely exhibits the phenomena of the solar and lunar halo, and also (as supposed from a few observations) the parhelion and paraselene. Hence the prognostic for foul weather is commonly drawn from the appearance of the halo. The distinct *cumulo-stratus* is formed between the first appearance of the fleecy cumulus and the commencement of rain; also during the approach of thunder storms. The indistinct appearance is chiefly between showers of rain, snow, or hail. A large lofty dense cloud is formed, comparable to a mushroom with a very thick short stem. But when a whole sky is crowded, the appearances are less distinct. The cumulus rises through the interstices of the superior clouds; and the whole, seen as passing off in the distant horizon, presents to the fancy mountains covered with snow, intersected with dark ridges and lakes of water, rocks, towers, &c. When the cumulus increases rapidly, a cirro-stratus is often seen to form around and repose on its summit, as on a mountain; while the former cloud continues discernible through it. The cirro-stratus soon becomes denser, and spreads; while the superior part of the cumulus extends, and passes into it, the base continuing as before, and the convex protuberances changing their position till they present themselves laterally and downward.

The *nimbus*, or *cumulo-cirro-stratus*, is the cloud of rain. Before rain occurs, the clouds uniformly undergo a change, attended with appearances sufficiently obvious to constitute a distinct modification. According to Mr. Howard, the cirrus is the highest; the cirro-cumulus next; and the cirro-stratus, cumulus, *and stratus*, in succession below each other. The nimbus, which is the resolution of clouds into rain, may be considered as having its base on the earth, and its summit at the end of the fibres of cirrose crown. Saussure writes of the very great height of clouds, which from the description must be a kind of cirro-stratus in mottled beds; and Dalton mentions, that the clouds of the mackerel-back sky have appeared almost as distant from the top of high mountains, as from the ground. Aeronauts have generally ascended much beyond the cumuli; but there are clouds much higher than any balloons have ascended. Mr. Sadler says, that large cumuli seen by him, when at a much greater elevation in a balloon, appeared like small silvery specks on the ground; his distance from them being so great, that they appeared to rest on the earth's surface.

CLYSSUS. A word formerly used to denote the vapour produced by the detonation of nitre with any inflammable substance.

COKE. Coal is charred in the

same manner as wood to convert it into charcoal. An oblong square hearth is prepared by beating the earth to a firm flat surface, and puddling it over with clay. On this, the pieces of coal are piled-up, inclining toward one another, and those of the lower strata are set up on their acutest angle, so as to touch the ground with the least surface possible. The piles are usually from 30 to 50 inches high, from 9 to 16 feet broad, and contain from 40 to 100 tons of coal. A number of vents are left, reaching from top to bottom, into which the burning fuel is thrown, and they are then immediately closed with small pieces of coal beaten hard in. Thus the kindled fire is forced to creep along the bottom, and when that of all the vents is united, it rises gradually, and bursts out on every side at once. If the coal contain pyrites, the combustion is allowed to continue a considerable time after the disappearance of the smoke, to extricate the sulphur, part of which will be found in flowers on the surface; if it contain none, the fire is covered up soon after the smoke disappears, beginning at the bottom and proceeding gradually to the top. In 50, 60, or 70 hours the fire is in general completely covered with the ashes of char formerly made, and in 12 or 14 days the coke may be removed for use. In this way a ton of coals commonly produces from 700 to 1100 pounds of coke.

In this way the volatile products of the coal, however, which might be turned to good account, are lost; but some years ago, Lord Dundonald contrived and carried into effect, a plan for saving them. By burning the coal in a range of 18 or 20 stoves, with as little access of air as may be, at the bottom; and conducting the smoke, through proper horizontal tunnels, to a capacious close tunnel 100 yards or more in length, built of brick, supported on brick arches, and covered on the top by a shallow pond of water; the bitumen is condensed in the form of tar: 120 tons of coal yield about 3½ of tar, though some coals are said to be so bituminous as to afford ⅙ of their weight. Part of the tar is inspissated into pitch, 21 barrels of which are made of 28 of tar; and the volatile parts arising in this process are condensed into a varnish, used for mixing with colours for out door painting chiefly. A quantity of ammonia too is collected, and used for making sal ammoniac. The cakes thus made are likewise of superior quality.

COAL may be divided into brown and black. The former, sometimes called wood coal, is chiefly found in alluvial ground. It contains besides charcoal and bitumen, vegetable principles, and remains of vegetables partially decomposed, which mark the origin of this kind of coal.

Wood coal or brown coal is an alluvial production; it is found in low situations, and appears to have been formed of heaps of trees buried by inundations under beds of clay, sand, or gravel. The woody parts have probably undergone a certain degree of vegetable fermentation under the pressure of the incumbent earthy matter by which they have been carbonized and consolidated. In some specimens of this coal, the vegetable fibre or grain is perceptible in one part, and the other is reduced to mineral coal.

Wood coal is found in considerable quantities at Bovey Heath end, near Exeter. Several beds of coal are separated by strata of clay and gravel; the lowest is 17 feet thick, and rests on a bed of clay, under which is sand resembling sea sand. The coal in contact with the clay has a brown colour, and appears intermixt with earth. In other parts the laminæ of the coal undulate, and resemble the roots of trees; in the middle of the lowest stratum the coal is more compact, and is of a black colour, and nearly as heavy as common coal. It is supposed that the species of wood of which Bovey coal was formed, is fir, as stumps of large fir trees, fixed by their roots in the ground, may be observed in the vicinity. These trees were probably deposited by successive

inundations, when the higher parts of the country were covered with primæval forests and peat moors. A great repository of this kind of coal exists near Cologne: it extends for many leagues: it is fifty feet in thickness, and covered with a bed of gravel from twelve to twenty feet deep. Trunks of trees deprived of their branches are embedded in this coal; which proves that they have been transported from a distance. Nuts which are indigenous to Hindostan and China, and a fragrant resinous substance, are also found in it. In wood coal, we may almost seize nature in the fact of making coal before the process is completed. In some peat moors the lower beds are compact, and approach nearly to the nature of coal; and it is said that peat has been discovered passing into mineral coal. These formations of coal are probably of more recent date than common coal, though their origin must be referred to a former condition of the globe, or to some grand catastrophe which has brought to northern latitudes the vegetable productions of tropical climates. Granting the vegetable origin of coal, we shall have no difficulty in accounting for an accumulation of carbon sufficient for its formation in every district where coal has been discovered. In the early ages of the world, the greater part of its surface was a dreary solitude covered by vast forests, and by marshes and peat moors, which were constantly accumulating vegetable matter. This might be carried away by great inundations, and deposited in hollows which formed temporary lakes; as these became dry, the vegetable matter which floated on the surface of the water would be left on the ground. Before fresh vegetable matter was formed, subsequent inundations might cover the former deposition with beds of sand or clay. Other depositions of vegetable and earthy matter might follow in succession, and fill up the hollow which formed the temporary lake.

The greatest difficulty respecting the origin and formation of coal strata, is the regularity with which they are arranged, and the frequent succession of thin strata or laminæ of coal in the same coal field. These are too thin and too regular to be formed by large vegetables, except in a state of perfect decomposition. They may have originated from aquatic plants or mosses growing in the place after each inundation. In most coal fields there are thin strata of coal-smut or carbonaceous and other particles intermixt, which seem to favour the opinion of the formation of coal strata by successive inundations; their subsequent consolidation may be less difficult to conceive.

By vegetable fermentation and compression, and by the evolution of heat from both these causes, the various strata may have consolidated. And if, with the Plutonists, we admit the action of central subterranean fire, it may also have contributed to the more complete destruction of vegetable organization.

Pressure and time alone may be sufficient to produce these effects partially, as is proved by the complete consolidation of loose materials left in coal mines when the supports are removed and the upper strata sink down. In a few years scarcely a trace of former operations remains. In contemplating natural causes, we are too apt to measure their power by the results of artificial processes, and by observations continued for a short portion of human life. The substances found in the neglected vessels of the chemist, often prove to us that changes in the physical properties of bodies are effected by time, which it would be impossible to imitate in common experiments.

Mineralogists have enumerated many different kinds of black coal: several of these pass by gradation into each other in the same mine. The most important varieties in an economical view are the hard coal, like that of Staffordshire, and bituminous or caking coal, called in London sea coal. Black coal is composed of charcoal, bitumen, and earthy matter. The latter

forms the ashes which remain after combustion: these vary in proportion, in different coals, from 2 to near 20 per cent. The proportion of bitumen varies from 20 to 40 per cent. and the charcoal from 40 to more than 80 per cent. The most common repository of coal is argillaceous sand-stone: it is never found in chalk or roc-stone, and very rarely in lime-stone. Coal exists in strata, which vary in thickness from a few inches to several yards. The strata are of limited extent: they occur over each other, separated by strata of clay or stone. The series of strata existing in one situation is denominated a coal field. Each coal field has its peculiar series of strata that appear to have no connection with any other: hence they are denominated by Werner "independent coal formations." The different strata which accompany coal, consist of beds of clay, some of which frequently contain fresh-water muscle-shells, beds of sand-stone of various qualities, argillaceous shale coloured with bitumen, called coal shale, loose stones called rubble, and strata of iron-stone. Many of these strata abound in vegetable impressions of ferns, and of other plants which are either unknown genera or belong to *tropical* climates.

The different strata under a bed of coal are frequently similar to the strata over it, and the same series is again repeated under the lower beds of coal. Sometimes a single bed of stone of vast thickness separates two beds of coal. In other instances only a very thin stratum of shale or clay lies between coal beds.

Numerous beds or seams of coal occur in one coal field, but very rarely more than three of these are worked. The thickness of coal seams or beds varies from a few inches to several yards; but each of these generally preserves the same thickness throughout its whole extent, when not broken by dislocations of the strata. Instances to the contrary sometimes occur, in which the same bed will be narrower or wider, and sometimes divided by a stratum of incombustible earthy matter, in different parts of its course. Few beds of coal are worked to any great depth which are less than two feet in thickness. The stratum lying over a bed of coal is called the roof, and the stratum under it the floor. The facility of getting coal depends very much on the compactness of the stone which forms the roof, not only on account of the security from falling, but for keeping out the upper water and preserving the pit in a dry state. The great expense incurred in supporting the roof when it is loose, frequently prevents a valuable bed of coal from being worked, or absorbs all the profit. In some situations the roof is indurated clay, impregnated with bitumen and pyrites. When this falls down, and is intermixt with water and small coal at the bottom, it takes fire spontaneously; on which account the miners close up the space with clay where the coal has been worked, to prevent the access of air to the combustible matter. This kind of clay is called '*fow*,' it is common in the Ashby de la Zouch coal field, and in Staffordshire.—Coal strata are frequently bent in concavities, resembling that of a trough or basin, dipping down on one side of the field and rising on the other.

In the great coal field in South Wales, the strata are arranged in this manner over an extent of one hundred miles. At the Clee Hills, in Shropshire, the breadth of some of the coal fields is not a mile. At Ashby Wolds, in Leicestershire, in the central part of the field the main bed of coal is worked at the depth of 240 yards; but by the bending and rise of the strata, the same bed comes to the surface about three miles distant. The depth of coal strata is very different in different situations, and, from the inclination or bending of the strata, differs much in the same district. Some coal fields extend in a waving form over a district.

On the eastern side of England, the strata generally decline, or in the miner's language, dip to the

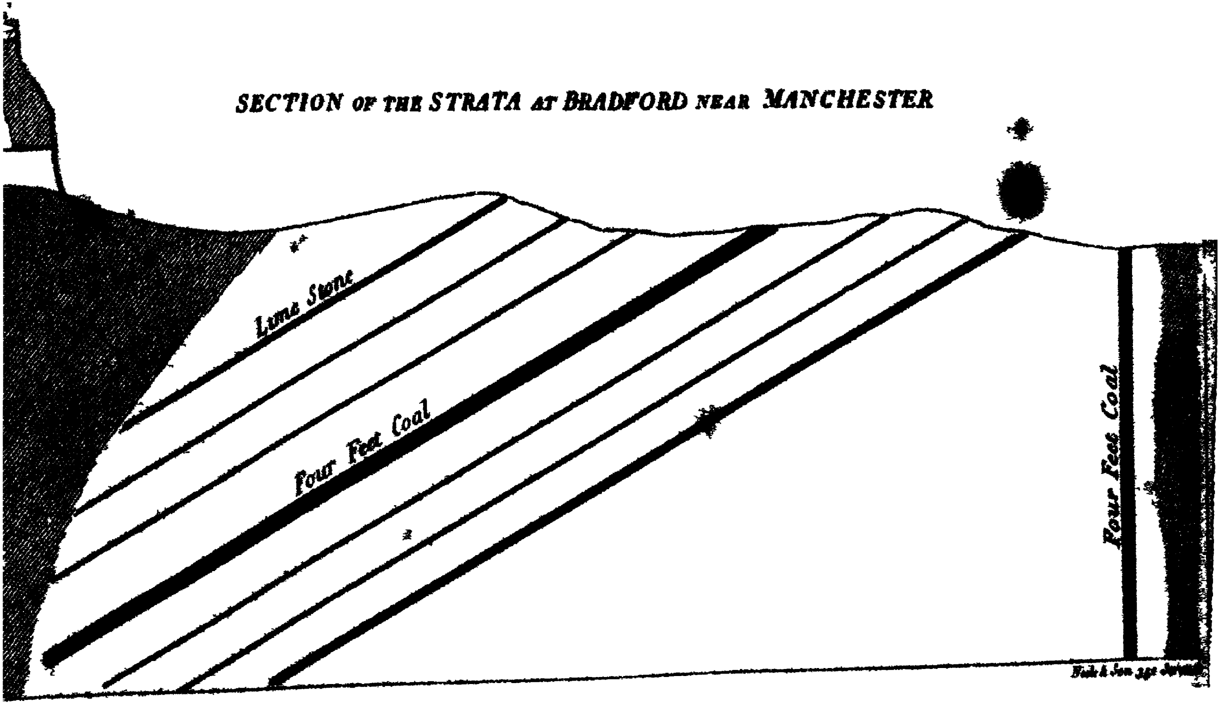
south-east point: on the western side, the strata are more frequently thrown into different and opposite directions by faults or dykes; the fractures of this kind, are filled with clay or stones of various descriptions.

In some instances the coal strata are thrown down or raised on one side of a dyke more than 150 yards, and the miner after penetrating through it, instead of finding the same coal again, meets with beds of stone or clay on the other side: hence he is frequently at a loss how to proceed in searching for the coal which is cut off; on which account such dykes are called *faults*. If the stratum of stone be the same as any of the strata which were sunk through in making the pit or shaft, it proves that the bed of coal is thrown down on the side of the fault, and he can determine the exact distance between that stratum and the coal he is in search of. But if the stone is of a different kind to any which was above the coal, he may be certain that the strata are raised on that side; but to what distance can only be ascertained by trial, if the under strata of the coal bed have not been previously perforated. It frequently happens, however, that two or more strata of stone or shale, at different depths, are so similar in their quality and appearance that it is impossible to distinguish them: in such cases it is necessary to perforate the stratum to ascertain its thickness and examine the quality of the strata above or below it, by which its identity with any known stratum may generally be ascertained. The manner in which the strata are inclined towards the fault will also determine whether they are thrown up or down, provided they are not shattered where they come in contact with it, which is frequently the case. Each bed of coal in a coal field has certain characters by which it may be known to be the same. Its thickness, and the quality of the roof and floor, with that of the upper and under strata, generally serve to identify it, though it may sink deeper in one place than another, and vary in distance from the surface 500 feet. The deepest coal mines in England are those in Northumberland and in the county of Durham, some of which are worked more than 300 yards below the surface. The thickest bed of English coal of any considerable extent is the main coal in Staffordshire, which is 30 feet. The upper, lower, and middle parts of the bed differ in quality. Mr. Keir, who has written an interesting account of the mineralogy of the south of Staffordshire, says that thirteen different kinds of coal occur over each other in this bed; the uppermost, which is compact, serves as a roof in getting the under coal. The main bed of coal in the Ashby de la Zouch coal field is 13 feet thick; the upper and lower seams of this bed also vary in quality, and the top serves as the roof, being more compact than the stratum over the coal. Few beds of coal in other parts of England or in Wales exceed from six or nine feet in thickness; but a difference in the quality may generally be observed in the upper, lower, and middle parts of the same bed. A curious fact is stated by Mr. Keir respecting the main coal of Staffordshire:—in one situation the upper part of the bed separates from the lower, and rises to the surface, or crops out. It is at first divided by indurated clay called bind or clunch; but as the distance becomes wider, the intervening stone grows harder, and will strike fire with flint.

Coal strata, beside the more common dislocations by faults, present remarkable contortions which it would be difficult to explain, except by admitting a lateral force which has compressed them into a zig-zag form. In some instances one part of a stratum is inclined, and the other part vertical. A curious fact of this kind may be seen in a small coal field near the town of Manchester.

There is more than one third of England, in which all search for valuable coal is useless: the knowledge of a negative fact becomes important when it saves us from loss of time, expense, and disappointment.

SECTION OF THE STRATA AT BRADFORD NEAR MANCHESTER



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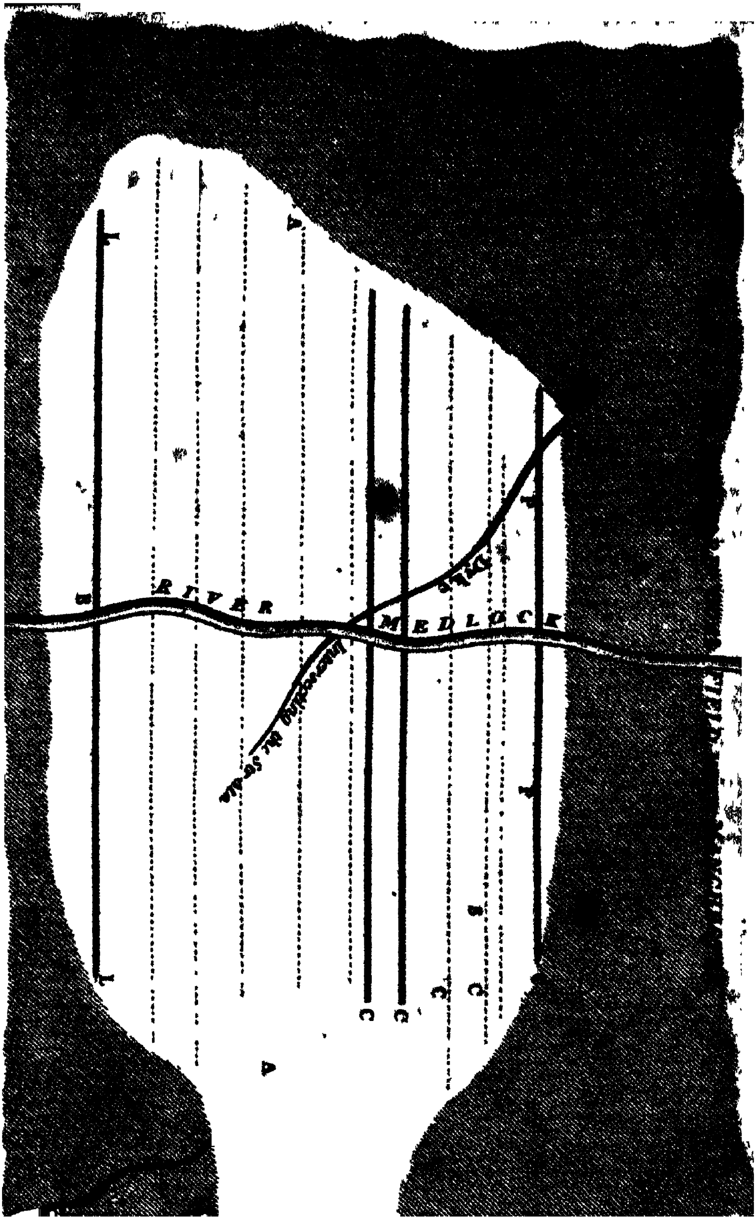

RIVER MEDLOCK
Dyke
Intersecting the Strata

Coal strata are frequently accompanied by thin strata of a compact argillaceous stone, combined with the oxide of iron called ironstone. This stone has a dark brown or grey colour: it is about three times heavier than an equal bulk of water. If it be of a good quality it yields more than 30 per cent. of iron. In some of the beds of clay over coal detached nodules of iron-stone occur, which are also smelted for iron.

The vast extent and importance of our iron-works are well known, but their establishment is of recent date. Formerly our foundries were on a diminutive scale, and wood or charcoal was the only fuel employed; but in the present cultivated state of the country wood could not be procured in requisite quantity. The extensive iron-works of Messrs. Ferraday in Staffordshire are said to consume one thousand tons of fuel per week. The application of coal or coke to the smelting of iron is among the most useful of modern improvements; but it is only some kinds of coal that are proper for the purpose. Inattention to this circumstance has frequently led landed proprietors to great unprofitable expense. Finding iron stone and coal in abundance upon their estates, they have constructed furnaces and other works at a considerable cost, and have found too late that the coal, however suitable for domestic or other uses, was unfit to make iron of a marketable quality. To make good iron from the best iron-stone, it is necessary that the coal should be as free as possible from every substance with which sulphur is combined. It should possess the property of forming a hard coke or cinder; and if it have the quality of cementing or caking, it is the more valuable, as the small coal can be used for the purpose of coking, which is frequently wasted where it does not possess this quality.

From the inclination or bending of coal strata, they always rise to the surface in some parts of their course, and would be visible if not covered by soil or gravel. In the intersections formed by rivulets, or by accidental fractures on the sides of hills in a district, the nature of the strata may often be determined, and should be ascertained before any expense be incurred in boring or sinking for coal. When this is done, a proper station should be chosen; which requires great judgment, otherwise it is possible to bore or sink to great depths, and miss a bed of coal which exists very near the place. In most situations it is better to search for coal, as deep as can be done without expensive machinery, by sinking a well in preference to boring. By sinking, a decisive knowledge of the nature and thickness of the strata can be ascertained as far as you descend, which can only be imperfectly known by boring; for the latter mode is liable to great uncertainty of result, from bendings or slips of the strata. Besides the uncertainty of the results, the grossest impositions are sometimes practised to answer interested purposes, and induce proprietors to continue the search where there is no reasonable probability of success. Where coal strata come to the surface, they are generally in a soft decomposed state, and intermixt with earthy matter. They frequently present no appearance of coal, but the soil may be observed of a darker colour. The real quality of the coal cannot be ascertained, until it is found below in its natural undecomposed state, lying between two regular strata of stone, or indurated clay. In general it is observed, that the same bed improves in quality, as it sinks deeper into the earth.

COAL GAS is of the highest importance, from the beautiful light which it yields, with which the metropolis and most of the principal towns are lighted. It is now in use in Germany and Russia, and steps are taking to introduce it on a large scale into Paris. When coals are burning on the fire, we see the stream shooting out, and inflaming when a light is held near it. To obtain gas the coals are enclosed in iron retorts, to which heat is applied, the gas rises up in the retort, and is made to

pass through water and other substances to free it from impurities. It is collected in a gasometer, from which it is transmitted by pipes to whatever distance it may be required, with the same facility as if it were water from a reservoir; indeed with greater ease, as the level of a reservoir of water must always be higher than the place to which water is conducted; but from the buoyancy and lightness of gas, it will ascend to any height to which it may be desirable to conduct it.

The gas produced from coal is chiefly the carburetted hydrogen gas, which consists of carbon and hydrogen, chemically combined. This is, however, by no means in a state of purity, but is only the predominant gas in the mixture. Mr. Accum thus distinguishes the several varieties of coal gas:—

"I have never met with any *coal gas* consisting of *pure carburetted hydrogen.* It has always proved, in the cases where I had an opportunity of examining it, a mixture of carburetted hydrogen, carbonic oxide, and hydrogen gas, the proportions of which vary according to the nature of the coal and of the process. When the heat is applied suddenly, and when it amounts to a good red heat, the proportion of carburetted hydrogen is greatest; and when the heat is low, the portion of pure hydrogen is greatest. Olefiant gas and sulphuretted hydrogen are, probably, likewise present, though in small and variable quantity. There is another circumstance connected with this gas, which has not hitherto been noticed, but which must have some influence upon the light which it yields. Coal gas has always the very same smell as the oil or naphtha which coal yields when distilled; therefore, it obviously contains a certain portion of naphtha mixed with it, in the state of vapour. When naphtha is put in contact with a quantity of common air, or indeed of any gas whatever, a portion of it mixes with the gas, in the state of vapour, and communicates to it the peculiar smell by which it is distinguished. Gas thus contaminated by the vapour of naphtha is not easily purified. It may be allowed to remain in contact with water, or even passed through water, without losing any of the naphtha vapour. The quantity of this vapour contained in coal gas depends upon the temperature of the naphtha and gas, when placed in contact. At the temperature of 55° the bulk of air, when placed in contact with naphtha, is increased 3 per cent. I find that the specific gravity of vapour of naphtha is 2.20, that of common air being 1.00. From this, it will not be difficult to determine the quantity of naphtha with which coal gas is usually contaminated. One volume of vapour of naphtha, for complete combustion, requires rather more than 2.4 volumes, but not quite so much as 2.5 volumes of oxygen gas. As carburetted hydrogen gas, carbonic oxide, hydrogen, and olefiant gases, are all destitute of smell, and as coal gas has always a strong smell of naphtha from which it cannot be, or at least has never yet been deprived, I conceive that the presence of the vapour of naphtha in it will not admit of a doubt."

Dr. Thomson has discovered a new compound inflammable gas, and has called it, from the nature of its constitution, *hydroguretted carbonic oxide.* Its specific gravity is .913, that of common air being 1. It is not absorbed nor altered by water. It burns with a deep blue flame, and detonates when mixed with oxygen and fired. It is a compound of oxygen, hydrogen, and carbon; Dr. Thomson considers it as being three volumes of carbonic oxide, and one volume of hydrogen, condensed, by chemical combination, into three volumes.

Observations on the production of coal gas.—The mode of lighting streets, houses, &c. with gas from coal, is an invention of the nineteenth century. We all remember the dismal appearance of our most public streets previous to the year 1810; before that time, the light afforded by the street lamps hardly enabled the passenger to distinguish a watchman from a thief, or the pavement from the gutter. The case is now different, for the gas-

lamps afford a light little inferior to day-light, and the streets are consequently divested of many terrors and disagreeables, formerly borne with, because they were inevitable.

The gas with which these lamps are supplied, is not generated on the spot, but in many cases, at a very great distance. For the supply of several districts in London and other towns, the gasometer and other apparatus for producing, and purifying gas from coals, are situated in some convenient place, from whence the gas is conveyed in metallic pipes to the lamps where it is destined to undergo combustion.

We shall here describe the mode of preparing gas. The coals are introduced into the cast iron retort or cylinder, which is placed on its side in the furnace. The retort is then closed by an air-tight metallic plate, which is fastened to it by bolts and nut-screws. The lower part of the retort is preserved from the action of the fire by a larger half cylinder of cast iron, enclosed in brick-work, placed at some distance below it; by which means, the heat is more equally distributed to the pit-coal.

A cast iron pipe proceeds from the upper side of this cylinder to a cast iron receiver, which is situated at the bottom of the well in which the gasometer rises and falls; in this receiver the tar and other condensible products are collected, and are extracted from time to time, by means of a pump affixed to it.

From the top of this receiver proceeds another iron pipe, which reaches to the surface of the water in the well, but which is inserted into an air-holder of about 18 inches in diameter, and two feet long, made of iron. The lower part of this air-holder is pierced with holes, which serve a double purpose, first to divide the gas into several small streams, and thus to render it purer by washing it as it passes through the water; and secondly, it serves as a reservoir of gas, from whence the tar receiver, connecting tubes, and even the retort itself, may be filled with gas whenever an absorption takes place, by the retort being cooled, or otherwise. The gas is discharged from this air-holder into the gasometer, which is suspended over the well, and rises and falls therein, being balanced by two weights passing over pullies. This gasometer is made of wrought iron plates, luted in the seams, so as to be air-tight, and well painted both within and without; it has an iron pipe made fast in the centre by means of two sets of stays, one at the bottom of the gasometer, and the other at the top. An upright pipe, fixed in the centre of the well, passes up the central pipe of the gasometer when it is depressed in the well. The gas is pressed out of the gasometer through a row of holes at the very top of the central pipe, into that pipe, whence it passes into the centre pipe of the well, which is continued across the well, and up the side, and from thence is branched out to the lamps. Each of these lamps will consume about six cubic feet of gas in an hour. They are composed of two concentric tubes closed at the bottom by an annular plate; the gas is introduced between them by a stop-cock in the side, and emitted for combustion, by a row of holes in the annular plate which connects the two tubes at the top. To assist the combustion, the current of air that passes through the inner tube, is directed against the flame by a button at the end of a wire, which slides up and down the inner tube: and thus the button can be placed at any required distance from the upper orifice of the tube. This current is also determined from the flame, by the upper orifice of the inner tube being enlarged. A glass chimney is also used, which is supported on an annular plate, pierced with holes to admit the air to the external surface of the flame.

As soon as coal gas came to be extensively applied to the purposes of street illumination, and to domestic use as a substitute for lamps and candles, it became an object of great importance to the proprietors and managers of the different gas-works, to ascertain with accuracy, the quantity of gas

expended, in proportion to the number of jets or burners made use of.

The essential conditions of any apparatus for this purpose are, that the pressure on the gas, while passing through the measurer, shall at all times be uniform: and that it shall register truly when that pressure is very small, and when the current of gas is very feeble.

The first gas-meter was constructed by Mr. Clegg, and is secured to the inventor by a patent. It consists, essentially, of a cylinder, divided into cells, enclosed and revolving in an outer cylinder, which is less than half filled with water. The gas enters laterally through the perforated axle, into that cell of the inner cylinder which happens to be nearest the surface of the water. It displaces the fluid from this cell, consequently destroys the equilibrium of the cylinder, and communicates to it a rotatory motion. When the cell, so filled with gas, has made nearly half a revolution, it comes again in contact with the water, which forces the gas out of the cell into the exterior cylinder, from which it passes into the conducting pipes. A train of clock-work is placed so as to register each revolution of the interior cylinder; and the cubic contents of this being known, of course the whole quantity of gas passing through the machine in a given time is ascertained.

Mr. Malam's gas-meter is constructed on the same general principles, but with such improvements, as induced the Society of Arts to confer on him a high honorary reward.

Mr. Peckston, who has paid much attention to the production and consumption of gas for illumination, in his work on this subject, divides coal into three classes. In order to give the reader a just idea of the qualities of each, we here transcribe his remarks upon each class, and subjoin tables drawn up by Mr. Accum, of the quantity of gas in cubic feet which may be produced from a chaldron of each variety.

"*Coals of the first class.*—Such coals as are chiefly composed of bitumen, are to be considered as belonging to the first class.

"This class gives light without difficulty, and burns with a bright and yellowish white blaze during the whole process of combustion. They do not cake nor require stirring, neither do they produce cinders, but are reduced to white ashes. Coals of this class are apt to throw out splinters whilst burning; but that may, in a great measure, be obviated by wetting them prior to their being used. At the head of this class is to be placed *cannel coal.* Those of Lancashire, and such as are obtained on the western coast of this island, also belong to it. It sometimes occurs in the coal-pits of Durham and Northumberland. Most of the varieties of Scotch coal may also be considered as forming part of it, and more particularly the *splent*, which is an inferior kind of *cannel coal.*

"Although this class of coal generally produces gas in considerable quantity, it is doubtful whether it be worthy of the gas light manufacturer's notice, and particularly in London; for, when it is submitted to distillation, there is no product of coke, as in coals of the second class; and, what is worse, the gas evolved is of so much greater specific gravity, that unless the gas holder be worked at an extremely light pressure, it will be highly offensive in the houses were it is consumed. It is not so easily purified as the gas procured from Bewicke and Craster's Wallsend coal, nor is it so beneficial.

"Some of the varieties of this class are, the Hartleys, Wylam, Tanfield Moor, Eighton Main, Cowper's Main, Blythe, and Pontops. Of these, Hartleys and Wylam are well adapted for heating retorts—the latter in particular. Tanfield Moor, though generating a very large proportion of heat, is not so; it is so very subject to *clinker*, and to destroy the grate bars, as well as the retorts and iron-work, as to render it very unfit for the purposes of generating coal gas for illumination.

One Chaldron of	*Cubic ft. of gas.*
" Scotch cannel coal produces	19,890
Lancashire Wigan coal	19,608
Yorkshire cannel coal (Wakefield)	18,860
Staffordshire coal,	
First variety	9,748
Second variety	10,223
Third variety	10,866
Fourth variety	9,796
Gloucestershire coal,	
First variety (Forest of Dean, High Delph)	16,584
Second variety (Low Delph)	12,852
Third variety (Middle Delph)	12,096
Newcastle coal,	
First variety (Hartley)	16,120
Second variety (Cowper's High Main)	15,876
Third variety (Tanfield Moor)	16,920
Fourth variety (Pontops)	15,112

" *Second class of coals.*—Those which contain a less proportion of bitumen, and more charcoal, comprehend the varieties of the second class.

" Coals of the second class do not burn with so bright a flame as the former. The flame of these coals is of a yellowish tinge. After lying some time on the fire, they become soft and swell: they then cake, and produce tubercles, from whence issue small jets of flame. When coals of this kind are burnt in an open grate, the passage of the air through them is prevented by the top of the fire caking and closely adhering. The consequence which follows is this, the lower part of the coal contained in the grate is consumed, and leaves a hollow, whence, if the upper part were not occasionally broken, the fire would go out. These coals produce a smaller proportion of ashes than coals of the first class. They are of a greyish or reddish colour, according to the quality of the earthy part of which the coal may be constituted. They produce hard grey cinders, which, being burnt over again with fresh coals, produce a very strong heat. The colour of the flame produced from this class of coal, is not so white and brilliant as that emitted by cannel coal, and those of similar properties; and that portion of it which is given out, after the bitumen it contains is disengaged, is of a pale blue colour. The gas which they produce, during this part of the process of combustion, is a mixture of oxide of carbon, hydrogen, and carbonic acid. The coke produced from this class of coal, during the process of generating gas therefrom, when carbonization is properly carried on, is well adapted for domestic and culinary purposes; and when such coal is manufactured into coke in the ordinary way, it is calculated to be used in the furnaces of iron-founders, and for other metallurgical operations. Coals of this class are, in the market, denominated *strong burning coals*. The coals which may be named under it, are Bewicke and Craster's Wallsend, Bewicke's Wallsend, Russell's Wallsend, Bell's Wallsend, Brown's Wallsend, Wear's Wallsend, Manor Wallsend, Wellington Main, Temple Main, Heaton Main, Killingworth Main, Headsworth, Hepburn Seam, Hutton Seam, and Nesham. Smiths prefer the smaller kind of this class of coals before any other, in consequence of its affording the greatest heat, the best cinders, and standing a strong blast. Swansea coals may be considered as belonging to this class. Some of the varieties contain pyrites, others thin layers of limestone and shells; these are found amongst the ashes they afford as slates and stones. When submitted to distillation, a greater heat is required than is necessary for decomposing coals of the first class; but the gas which they afford is easily purified, and is generally

better adapted for use than that obtained from coals of the first class. The aqueous fluid which passes over, during the process, contains sulphate, carbonate, and hydro-sulphuret of ammonia. When coals of this kind are mixed with those of the first class, in the proportion of two-thirds of the former with one-third of the latter, an excellent fuel is thereby formed; and if, in making the mixture, the proportion of coals of the first class be increased, the fuel will be more easily managed, and will burn with greater cheerfulness; but then its durability will decrease in a like proportion.

One Chaldron contains	*Cubic ft. of gas.*
" Newcastle coal,	
First variety (Russel's Wallsend) !	16,876
Second variety (Bewicke and Crastor's Wallsend	16,807
Third variety (Heaton Main)	15,876
Fourth variety (Killingworth Main)	15,312
Fifth variety (Benton Main)	14,812
Sixth variety (Brown's Wallsend)	13,600
Seventh variety (Manor Main)	12,548
Eighth variety (Blythe)	12,096
Ninth variety (Burdon Main)	13,608
Tenth variety (Wear's Wallsend)	14,112
Eleventh variety (Eden Main)	9,600
Twelfth variety (Primrose Main)	8,348

Third class of coals.—The third class are such as contain very little bitumen, but are chiefly composed of charcoal, chemically combined with different earths.

" Coals of this class require a very high temperature to bring them into ignition; they do not burn till wholly ignited; and then some of the varieties produce a very weak flame; others neither yield flame nor smoke, and merely produce a red heat like that which is generated by charcoal, when under combustion. They contain a very considerable portion of charcoal; they produce only a small quantity of ashes, but these are generally very heavy. When distilled in close vessels, they do not produce much tar; and that portion which is disengaged, comes over in a state nearly resembling melted pitch. Under that process, they also yield a gaseous fluid composed of gaseous oxide of carbon, hydrogen gas, and a considerable portion of sulphuretted hydrogen. Considering the nature of the different varieties of this class of coals, it can hardly be expected, that it would be profitable to use them for generating coal gas. The Kilkenny, Welsh, and Stone coal, are varieties forming this class.

One Chaldron contains	*Cubic ft. of gas.*
" Welsh coal,	
First variety, from Tramsarem, near Kidwelly	2,116
Second variety, from the yard vein at the same place .	1,656
Third variety, from Blenew, near Llandillo	1,416
Fourth variety, from Rhos, near Ponty Barren	1,272
Fifth variety, from the vale of Gwendrath	1,292
Sixth variety, from ditto	1,486

Mr. Brande states that the produce of one chaldron of good coals, will be,

	£.	s.	d.
In coke, $1\frac{1}{4}$ chaldron, at 31*s*.	1	18	9
In tar, 12 gallons, at 10*d*.	0	10	0
Ammoniacal liquor, 18 gallons, at 6*d*.	0	9	0
Gas, 20,000 feet, at £1. for 1,252 feet	16	2	3
	£19	0	0

By Mr. Clegg's improvements in the production of gas, 25,000 cubic feet are generated from one chaldron of Wallsend coals, without the formation, either of tar or ammoniacal liquor, being 15,000 cubic feet more than was formerly produced. The coal is introduced, by a mechanical process, in strata not exceeding half an inch in thickness. In this way, the retorts are kept at an uniform heat, and the coal is completely and rapidly decomposed, so that the whole of the hydrogen combines with the charcoal, constituting olefiant gas; and the matter which usually escaped in the form of tar and ammoniacal liquor is perfectly decomposed. The expense of producing 50,000 cubic feet of gas in twenty-four hours on the old plan is £3,817., upon the new plan £1,123.; and the expense of producing an equal quantity of light from oil £19,010.

If the tar which is obtained from the distillation of coal for gas light, be made into a paste with saw-dust, and put into the retort, it will yield gas in greater abundance than the best coal, and of an excellent quality.

Messrs. Taylor and Martineau are in the habit of constructing apparatus for the production of gas, for illumination, from oil. A very handsome and convenient apparatus of this sort has been erected in the laboratory of the Apothecaries' Company, Blackfriars, London.

For the purification of coal gas from sulphur and other substances by which it is apt to become contaminated, various methods have been tried and adopted. All these methods depend upon the affinity which exists between the sulphur, &c. and those substances used in the purification. The first of these inventions which we shall notice, is that of Mr. Palmer.

"The gas (says Mr. P.) may be made by any of the usual processes, and is to be conveyed in pipes to a condensor or refrigeratory, to deprive it of its tar, ammoniacal liquor, and condensible ingredients. From thence it is to be conveyed to one of my purifiers, which consists of a vessel of any form, and made of cast iron, or any other material which will stand the action of heat. This purifier is to be kept moderately red-hot while in action; to accomplish which, it may be set in the same furnace as the retorts, or heated by a separate fire (which will be governed by the nature and extent of the concern), so as to be visibly red by day-light. It must be understood that I mention this temperature as being sufficient, although a higher one will not be detrimental to the process, but will destroy the purifying vessel more rapidly.

"This purifying vessel is to be nearly filled with the fragments or refuse clippings of sheet iron, tinned iron plates, or any oxide of iron at a minimum of oxidation, such as common clay or argillaceous iron ore, or finery cinders, or black oxide of iron; and, when so filled and heated, the gas must pass through it. This will effect a partial decomposition of the sulphuretted hydrogen, to complete which it must pass into a box or cistern of cold water. The pipe which conveys the gas into the box or cistern, should just dip into the water, and a pipe at the top of the cistern must communicate with the gasometer, into which the gas will flow perfectly pure, and can then be distributed and burnt as usual. The operation of this method of purification must be obvious to those who are acquainted with chemistry; for it will be readily observed, that the sulphuretted hydrogen contained in the gas will be decomposed, by the action of heat and the substances used, into hydrogen and sulphuric acid, whilst, at the same time, no sulphurous acid gas can escape the agents to which the crude gas is exposed.

"Whenever it is ascertained, by smell or chemical tests, that the gas does not come over completely purified, it will determine, that the contents of the purifier are saturated, and the gas must then be turned off by an arrangement of cocks or valves to another purifier, similar, in every respect, to the one described; observing, that when one of the purifiers is thrown out of action, it need not have its

contents removed, but merely exposed to the action of the atmosphere by the removal of its covers; and as it is still kept red-hot, it will, before the purifier just named becomes saturated, be again competent to purify the gas. The purifier should not be worked longer at one time than from six to twelve hours each, which time must be governed by the quantity of gas passed through them. This method of proceeding must be invariably observed with each purifier, working them alternately until it is ascertained that the metallic iron is rendered useless; in which case the purifier must be discharged of its contents, and filled with fresh.

"The pipes connected with the purifiers, for the admission and discharge of the gas, should have an immediate fall, so as to prevent the condensible products from returning back into the purifiers; for this would destroy the play of chemical affinities between the sulphuretted hydrogen and the metallic iron, by covering its surface with a carbonaceous crust."

The next method of purifying is, by using fresh burnt earths to combine with the sulphur. It was invented by Mr. Haddock.

In the first place, he charges the retort with a quantity of pit-coal proportionate to the size thereof, and then adds thereto one-eighth part, by weight, of well burnt fresh lime, baryta, strontia, or any other alkaline earth or substance, having a strong affinity for sulphur, such substance being first perfectly freed from carbonic acid; but he prefers lime, as being the cheapest, and, in his opinion, best adapted to the purpose. He next causes the products emitted from the retort to pass through a red-hot cylinder, or other shaped vessel, filled with well burnt fresh lime, free from carbonic acid, or with any other substance or substances free from carbonic acid, oxygen, ammonia, or sulphur, and not possessing the property of giving an injurious quality to carburetted hydrogen gas. He introduces such lime, or other substance or substances, to check the too rapid progress of the volatile ingredients emitted from the retort, in order that any yet undecomposed petroleum may be converted into carburetted hydrogen.

The red-hot cylinder, or other shaped vessel, must be immediately connected with the retort, so as to prevent as much as possible, the condensation of any petroleum. He then causes the gas to be passed through a washer of water, acidulated with sulphuric acid, or any acidulated water capable of fixing ammonia; and he afterwards continues the process in the manner hitherto in practice.

The last method we shall mention is that of Mr. Grafton, he says:

"The material to be applied, for the purpose of taking up the sulphuretted hydrogen and carbonic acid gases, is a compound of lime with pot or pearl ashes and charcoal or coke, which is formed by pouring a strongly impregnated solution of pot or pearl ashes in water upon recently burnt and unslacked lime, the quantity of the solution required being so much as will slack the lime, or cause it to fall to powder. This done, add dry pot or pearl ashes about one-fifth of the whole weight of the lime, and also about one-fourth of the charcoal or coke broken into small pieces, the whole to be perfectly mixed together, which composition is to form the absorbent or purifying stratum.

"The purifying vessel is divided into several upper and lower compartments, the gas being intended to pass from one to another through the stratum of prepared lime as above compounded. This is spread upon a wire gauze web, extended horizontally through the middle of the vessel. The gas from the retorts, passing through the main is introduced into the purifying vessel at one end, when, having filled the first lower compartment, it rises through the stratum of lime, &c. extended over it into the upper compartment, having undergone an operation similar to filtering; by which a chemical union takes place between the slacked lime and the impure parts of the gas. From the upper compartment the gas descends again through the

stratum of lime into the second lower compartment, and from thence rises again through the purifying stratum into the second upper compartment, and so on; ascending and descending through strata of lime until it reaches the last chamber, having, by this operation, become purified, whence by a pipe it is conveyed into the gas-holder.

"The apparatus above alluded to, consists of a long box, having several partitions; and at each end of the box on the outside, is attached a cylindrical roller, over which is extended an endless web, or band, made of wire gauze: this endless web lies upon, and covers the top of the box lengthwise, passing under it; and upon its upper side over the box is distributed the layer or stratum of the above purifying compound.

"This apparatus is enclosed within another box or case, in the upper part of which several sliders are placed, which shut down close upon the wire gauze, at parts intervening between the partitions of the box below; forming the upper compartments above alluded to: between this and the lower compartments, the stratum or layer of lime, &c. is extended upon the wire gauze.

"There are also roller brushes under the wire gauze web, to cleanse it from any coagulated portions of the lime which may possibly adhere after the saturated stratum has been removed."

COATING, or LORICATION. Chaptal recommends a soft mixture of marly earth, first soaked in water, and then kneaded with fresh horse-dung, as a very excellent coating.

The valuable method used by Mr. Willis, of Wapping, to secure or repair his retorts used in the distillation of phosphorus, deserves to be mentioned here. The retorts are smeared with a solution of borax, to which some slaked lime has been added, and when dry, they are again smeared with a thin paste of slaked lime and linseed oil. This paste being made somewhat thicker, is applied with success, during the distillation, to mend such retorts as crack by the fire.

COBALT has never yet been found in a pure state, but always as an oxide, combined with other metals, in the form of a sulphuret, or combined with an acid. Nickel is very frequently combined with cobalt in the same ore. The following is Mr. Laguier's method of treating the ores of cobalt and nickel, and of separating these metals from each other:—Roast and pulverize the mineral called *speiss*, and dissolve it in nitric acid; evaporate the solution considerably, that the arsenic may subside in the form of an oxide; pour into the remaining clear solution, drop by drop, some carbonate of soda to separate the arseniates of iron, copper, and cobalt, till the precipitate becomes green; and as soon as this appears, the solution should no longer contain any other metallic matter than arseniate of nickel dissolved in nitric acid. Then decompose this arseniate, by passing a current of hydrosulphuretted gas through the liquor, till it ceases to become turbid; filter the liquor, heat it to drive off the excess of sulphuretted hydrogen; and lastly, saturate it with carbonate of soda to obtain a *pure carbonate of nickel*.

We treated the simple carbonate of nickel with oxalic acid, to separate any particles of oxide of iron that might have remained in union with it. We took an ounce of this impure oxalate of nickel in powder, put it into a stoppered bottle with concentrated ammonia, and shook it; solution took place, giving a very fine violet-blue. This solution kept in a close vessel, deposited in a few days very fine crystals of the same colour, but without any apparent separation of its constituent parts. We observed, however, that when a portion of the violet ammoniacal solution had been exposed to the air, it gradually changed to a green salt as it dried, but surrounded by another salt equally dry, which was rose-coloured.

We, therefore, dissolved a fresh portion of the impure oxalate of nickel in ammonia, and let it re-

main exposed to the air. In twenty-four hours much of the blue colour was lost, the red began to prevail, and a copious greenish-blue sediment fell to the bottom. On further exposure, we observed, that in proportion as the ammonia was dissipated, the solution became redder, the sediment increased, and its colour passed into a dark green. This sediment had a crystalline form, appearing in pellicles of needled and silky clusters on the sides and bottom of the vessel. In three days the separation was complete, the liquid, now of a deep rose-colour, hardly gave any ammoniacal smell, and was decanted from off the crystalline sediment. The latter was repeatedly rinsed with hot water without dissolving in it, in the smallest degree.

In this way we succeeded in purifying the cobalt completely; as the red solution of this metal retains none of the nickel, or at least a very minute quantity which separates spontaneously in a few hours, when the red liquid is largely diluted with water, for the oxalate of nickel is almost entirely insoluble in it. There is somewhat more difficulty in depriving the green sediment of oxalate of nickel of every atom of cobalt. To effect this, it must be dissolved, as at first, with pure ammonia, exposed to the air till the green sediment has separated, and then rinsed with hot water, the water containing the cobalt, becoming a slightly rose-coloured, and the insoluble oxalate of nickel becoming of a purer green. A repetition of this operation two or three times, will separate every atom of the oxalate of cobalt.

At first we employed concentrated ammonia, which made the experiments rather expensive, but we found that a more dilute ammonia would answer as well. The mixed oxalates of cobalt and nickel should be rubbed with it in a mortar, and the whole should then be poured into a phial, and frequently shaken till the solution is complete, which may be assisted by a gentle heat. When the ammonia is concentrated, the colour is violet; but blue, when more dilute. This, by exposure to air, produces, as above described, the deep red solution of oxalate of cobalt, which, by slow evaporation, crystallizes in fine garnet-coloured needles, which are readily soluble in water, but more so when heated. Ammonia also dissolves these crystals, both warm and cold, and the solution does not deposit an atom of nickel, which is a mark of its purity.

When this oxalate of cobalt is calcined, it leaves a deutoxide which dissolves in strong muriatic acid, with disengagement of chlorine. The solution at first is green, as if it contained iron or nickel, but this colour is only owing to the admixture of the yellow of the chlorine with the natural blue of the pure muriate of cobalt; and accordingly the liquid becomes of a very pure blue, as soon as all the cobalt has been brought to the state of protoxide, and the chlorine is expelled. If the blue muriate is exposed to the air for several days, the excess of acid is dissipated, the colour deepens to violet, and in time would probably become red, as happens when water is added.

On the other hand, when the solution is concentrated by a gentle heat, it takes a pure blue colour, and leaves a residue of the same; which, on the addition of a little water, forms a rose-coloured solution. This again becomes blue when heated, and much concentrated, and then crystallizes spontaneously into beautiful ruby-coloured prisms. These crystals of muriate of cobalt are not deliquescent if pure, nor does the mother liquid yield a deliquescent salt, unless the air is extremely moist, or unless any nickel is present; but if this occurs, the liquor becomes green. It is, therefore, to the presence of nickel that the supposed deliquescence of muriate of cobalt is to be attributed.

It appears, therefore, from these experiments, that cobalt and nickel brought to the state of oxalate, and treated by ammonia either concentrated or diluted with two parts of water, may be separated from each other; and we conceive that the following is the explanation of what takes place:—these

two oxalates are changed by solution in ammonia into triple salts of oxalic acid, ammonia, and the metallic oxide. What proves it, is, that after the extraction and separation, they both give out ammonia by the addition of potass. But the ammoniacal oxalate of nickel which dissolves so well in ammonia, is quite insoluble in water; and on the other hand, the corresponding salt of cobalt dissolves readily both in ammonia and in water. Hence, in proportion as the excess of ammonia evaporates by exposure of the compound solution to the air, the first precipitate that falls down is the triple salt of nickel; whilst the salt of cobalt remains till the further evaporation of the mere water necessary to its solution. Therefore, it is of advantage not to wait too long before the first deposit is removed.

As a proof that it is the excess of ammonia which holds the oxalate of nickel in solution, it may be added, that the compound solution will remain unchanged for months in a vessel hermetically sealed: or if they crystallize, it is in mass, and without any visible separation of one salt from the other.

Cobalt in a pure state, is of a steel grey colour, with a tinge of red, and a fine close grain. It has a granulated fracture, and is easily broken and pulverized. Its specific weight is between 7.700 and and 7.811. It requires a very intense heat for its fusion, nearly equal to that necessary to melt cast iron; when heated in contact with the air it oxidates before fusion. Phosphorus renders it very fusible, and converts it into a phosphuret. It unites to sulphur with difficulty, but very well with the alkaline sulphurets by fusion.—When alloyed with metals it renders them granulated, rigid, and brittle. It is attacked by a greater number of the acids, and unites with the boracic acid. Its solution in different acids becomes green when heated, and from this property it is used as an ink, which when written with on paper is invisible, but becomes visible when gently heated, and disappears when cold. It takes fire in oxigenated muriatic acid gas. It colours glass of a fine blue, it unites with platinum, gold, iron, nickel, copper, and arsenic, by fusion; but silver, lead, bismuth, and mercury, refuse to unite with it in the dry way. In its purest state it is not only obedient to the magnet, but if we may trust to the accuracy of some experiments made by Kohl and Wenzel, it may even receive a magnetical attractive power.

Nitrate of potash oxidates cobalt readily, it detonates by the blow of a hammer when mixed with oxigenated muriate of potash. It produces fine colours in porcelain enamels, artificial gems, &c.

The most remarkable production of Alderley Edge, in Cheshire, is cobalt ore, which was very recently discovered here, existing in the red sand-stone. It had long been unnoticed, or employed in mending the roads, until a miner, who had worked upon the continent and seen the cobalt ores of Saxony, first discovered it in the estate of a gentleman in the neighbourhood. The attention of the tenants of the Alderley mines was then directed to the subject, and the cobalt mines were let for one thousand pounds per annum to a company near Pontefract in Yorkshire. The proprietor of Alderley Edge is Sir J. T. Stanley, bart. whose grounds and seat are in its immediate vicinity. The ores of cobalt, so valuable to the manufactures of porcelain and paper, are very scarce in this island. They have been found in small quantities in Cornwall, chiefly of the kind called grey cobalt ore, which contains cobalt combined with iron and arsenic. The ore at Alderley is the black cobalt ochre of mineralogists. It is in the form of grains, of a bluish black colour. The best specimens in colour and appearance resemble grains of gunpowder disseminated in red sand-stone, or lying in thin seams between the stone, which has a schistous or slaty fracture. It lies from eight to ten yards under the surface, and is got out in thin pieces, and separated afterwards as much as possible from the stone it is then

packed in tubs, and sent near Pontefract, where it is manufactured into smalt.

Amidst the confusion of mineral substances at this place, there are some distinct features of regularity. The cobalt ore is stratified; and though near, is separate from the other ores; it is chiefly, if not entirely, in the red sand-stone. It lies near the surface, and is evidently of later formation than the other part of the hill; as the red sand-stone, where it is found, always lies upon or intersects the white. The latter stone is the repository of the other metals.

The quality of the smalt produced from the cobalt ore does not equal that made from foreign cobalt. Whether this inferiority arise from the nature of the ore, or some defect in the process of separation, may be doubtful. Cobalt is one of the most refractory metals in the hands of the chemical analyst. It is so intimately combined with iron, nickel, and arsenic, that its separation in a state of perfect purity is a process requiring great care, and attended with considerable difficulty. Cobalt, in its metallic form, has not been applied to any useful purpose. Amongst German miners, cobalt ores were long known before their nature or use was suspected. Finding frequently a black substance cut across the metallic veins, which impeded their progress in the mines, and occasioned them much trouble, they called it *cobbel*, the name of a fearful dæmon, the genius of the subterranean abodes; against whose wicked machinations their priests had a Latin form of prayer, in which he is styled Cobalus. In Yorkshire, where many Saxon words are retained, ignorant nurses still appal the terrified imagination of children with the threatened approach of *Cobby*.

Oxygen combines with cobalt in two proportions, forming the dark blue protoxide, and the black deutoxide.

The phosphate of cobalt is an insoluble purple powder, which, when treated with eight parts of gelatinous alumina, produces a blue pigment, a substitute for ultramarine. Oxide of cobalt has great effect in colouring glass, one grain gives a full blue to 240 grains of glass. Smalt and azure blue are merely cobaltic glass in fine powder. Zaffre is a flint powder, and an impure oxide of cobalt prepared by calcination of the ores.

COBALUS. An imaginary dæmon supposed to obstruct and destroy miners. It gave occasion to the metal cobalt being so named.

COCOLITE is a mineral of a green colour, consisting of silica 50, lime 24, magnesia 10, alumina 1.5, oxide of iron 7, oxide of manganese 3, loss 4.5. Specific gravity 3.3.

COCHINEAL was at first supposed to be a grain, which name it still retains by way of eminence among dyers, but naturalists soon discovered that it was an insect. It is brought to us from Mexico, where the insect lives upon different species of the opuntia.

Fine cochineal, which has been well dried and properly kept, ought to be of a grey colour inclining to purple. The grey is owing to a powder which covers it naturally, a part of which it still retains: the purple tinge proceeds from the colour extracted by the water in which it has been killed. Cochineal will keep a long time in a dry place. Hellot says, that he tried some, one hundred and thirty years old, and found it produce the same effect as new.

Cochineal, according to Dr. John, contains

Colouring matter	50.0
Jelly	10.5
Waxy fat	10.0
Gelatinous matter	14.0
Shining matter	14.0
Salts	1.5
	100.0

COLCHICUM AUTUMNALE.—A medicinal plant, the infusion of the root of which has been shewn by Sir E. Home, to have the virtue of alleviating the pain of gout.

COLOPHONITE. A mineral consisting of silica 35, alumina 13.5, lime 29, magnesia 6.5, oxide of iron 7.5, oxide of manganese 4.75

and oxide of titanium 0.5. Specific gravity 4.

COFFEE. The seeds of the *coffea arabica*, besides the peculiar bitter principle called caffein, contain several other vegetable products. Cadet found 64 parts of raw coffee to consist of 8 gum, 1 resin, 1 extractive bitter principle, 3.5 gallic acid, 0.14 albumen, 43.5 fibrous insoluble matter, and 6.86 loss.

There is a volatile fragrant principle arising from coffee whilst roasting, of which the nature is not thoroughly known. In Surinam, the Dutch hang up the coffee for two years in bags, before using it, and consider it as greatly improved in flavour thereby.

Coffee is diuretic, sedative, and a corrector of opium. It should be given as medicine in a strong infusion, and is best cold. In spasmodic asthma it has been particularly serviceable; and it has been recommended in gangrene of the extremities arising from hard drinking.

COHESION, (Attraction of). See Adhesion.

COHOBATION. The continued re-distillation of the same liquid from the same materials.

COLCOTHAR. The brown-red oxide of iron, which remains after the distillation of the acid from sulphate of iron: it is used for polishing glass and other substances by artists, who call it crocus, or crocus martis.

COLD. The privation of heat. The following experiment would make it appear at first view as if cold consisted of particles of matter, as has been supposed of heat, though, on farther consideration, the idea will appear totally unfounded. A piece of ice being placed in the focus of a concave mirror lowers the thermometer placed in the focus of a mirror placed opposite. But this arises not from any frigorific particles coming from the ice to the thermometer, but by the abstraction of calorific particles from the thermometer by the ice. If the thermometer had been at a lower temperature than the ice, instead of the mercury sinking it would have risen.

COLOPHONY. Colophony, or black resin, is the resinous residuum after the distillation of the light oil, and thick dark reddish balsam, from turpentine.

COLUMBIC ACID was first discovered by Mr. Hatchett. This accurate analyst being engaged in examining and arranging some minerals in the British Museum, observed a specimen of ore which greatly resembled the Siberian cromate of iron. It appeared that the mineral in question was sent from the mines of Massachusets, in North America.

Mr. Hatchett describes this ore as being of a dark brownish grey externally, and more inclining to an iron grey internally, the longitudinal fracture he found lamellated, and the cross fracture had a fine grain. Its lustre was vitreous, slightly inclining in some parts to metallic, moderately hard and very brittle. The colour of the streak or powder was dark chocolate brown. The particles were not obedient to the magnet. Its specific gravity, at a temperature of 65° Fahrenheit, Mr. Hatchett found to be 5.918.

A series of accurate experiments made by its discoverer, prove that this ore consists of iron combined with a new metallic acid, which constitutes more than three-fourths of the whole. The mode of analysis was as follows: One part of the ore reduced to powder was mixed with five times its weight of carbonate of potash, and fused in a silver crucible. An effervesence took place during this process. When this had subsided the whole was poured into a proper vessel and suffered to cool. Boiling distilled water was then poured upon it, and the whole was transferred upon a filter. The insoluble residuum was repeatedly washed in distilled water. The filtered fluid was now supersaturated with nitric acid. The result of which was a white flocculent precipitate, which was columbic acid.

COMBINATION. The union of the particles of different substances by chemical attraction, so as to form a compound possessed of new properties.

COMBUSTIBLE. A body which, in its rapid union with others, causes a disengagement of heat and light. To determine this rapidity of combination, a certain elevation of temperature is necessary, which differs for every different combustible.

Stahl adopted, and refined, on the vulgar belief of the heat and light coming from the combustible itself; Lavoisier advanced that the heat and light proceeded from the oxygenous gas, in air and other bodies, which he regarded as the true *pabulum* of fire. But many combustibles burn together without the presence of oxygen, or of any analogous supporters; as chlorine, and the adjuncts to oxygen, have been called. Sulphur, hydrogen, carbon, and azote, are as much entitled to be styled *supporters*, as oxygen and chlorine, for potassium burns vividly in sulphuretted hydrogen, and in prussine; and most of the metals burn with sulphur alone. Heat and light are disengaged, with a change of properties, and reciprocal saturation of the combining bodies.

Sound logic would justify us in regarding oxygen, chlorine, and iodine, to be in reality combustible bodies; perhaps more so than those substances vulgarly called combustible. Experiments prove that light as well as heat, may be afforded by oxygen and chlorine. If the body, therefore, which emits, or can emit light and heat in copious streams, by its action on others, be a combustible, then chlorine and oxygen merit that designation, as much as charcoal and sulphur. Azote is declared to be a simple *incombustible*. Yet its mechanical condensation proves that it can afford, from its own resources, an incandescent heat; and with chlorine, iodine, and metallic oxides, it forms compounds possessed of combustible properties, in a preeminent degree.

Combustibles have been arranged into simple and compound. The former consists of hydrogen, carbon, boron, sulphur, phosphorus, and nitrogen, besides all the metals. The latter class comprehends the hydrurets, carburets, sulphurets, phosphurets, metallic alloys, and organic products.

COMBUSTION is an operation which we constantly see going on, and yet it is but of late that any rational account could be given of it; and there are still circumstances respecting it which are but very imperfectly explained. We see dry pieces of wood, which feel cold to the touch, when a light or fire, in any shape, is applied to them, begin to burn; heat and light are at the same time emitted, and the wood is reduced to ashes. The same may be done to coals, to dry grass, to paper, linen, hemp, cotton, and a variety of bodies. Spirits of wine or oil may in like manner be burnt.

Dr. Thomson thus clearly explains what is meant by combustion: "When a stone or brick is heated, it undergoes no change except an augmentation of temperature; and when left to itself it soon cools again and becomes as at first. But with combustible bodies the case is very different. When heated to a certain degree in the open air, they suddenly become much hotter of themselves, continue for a considerable time intensely hot, sending out a copious stream of caloric and light. This emission after a certain period begins to diminish, and at last ceases altogether. The combustible body has now undergone a most complete change, it is converted into a substance possessing very different properties, and no longer capable of combustion."

Whilst this operation is going on there is a current of air proceeding towards the body which is burning. It has been ascertained that the oxygenous part of the air enters into combination with it, and is separated from the nitrogen of the air. In general combustion cannot go on without a supply of air. If an extinguisher be put on a candle when the supply of air is exhausted the candle goes out. If the extinguisher be soon removed, a part of the wick is still red; but if it remain over the candle a sufficient time it is totally extinguished. When charcoal is

made by partly burning the wood, in order to extinguish it after it is charred, earth is heaped up over it, when the supply of air is cut off and the burning ceases. In short, by whatever way we smother a fire, so that the air be denied access, it is put out. On the other hand, when we cause a stream of air to pass through a fire, whether by blowing it with a bellows, fanning it, or any other way, the fire burns more intensely.

The air of our atmosphere is made up chiefly of two substances, oxygen and hydrogen, combined with a large portion of caloric, which preserves them in their aeriform states, otherwise they would become solid. Now, when combustion takes place, it is ascertained, that the oxygen of the atmosphere is separated from the hydrogen, and enters into combination with the body which is burnt, and, as uniformly takes place when bodies are condensed or solidified, heat is forced out, the oxygen giving out all the heat which is felt at that time. It has already been stated, that the compression of air will give out both heat and light, and by the oxygen uniting with the combustible body they are both given out. A portion of the light, and indeed often a much larger portion of the light emitted, proceeds from the combustible body. Thus more light may be given out by burning a large candle than by a fire, and yet the quantity of oxygen consumed by the fire will infinitely exceed that consumed by the candle. The oxygen, however, combines with the combustible, and if it be wood or other matter consisting of carbon, the carbonic acid is formed by the union, which is carried by the stream of air up the chimney, or is dissipated on all sides round the fire. If a charcoal fire be put in a small room where there is no vent for the gas formed by combustion, the room will be filled up, and a person sleeping in it may be destroyed by breathing it. Such unfortunate accidents have too often occurred. The smoke that arises from a fire is merely the water or moisture converted into vapour mixed with a small portion of carbon. Hence, when a fire is made from charcoal or coke, where all moisture has previously been dissipated, there is no smoke produced. If a little water be poured on coals the smoke will be greatly increased. Green wood produces much smoke, and so also does wet straw. The flame produced from the fire is merely the smoke ignited or burnt by the heat, and only that part of it is ignited which comes in contact with the air. The flame of a lamp or candle may be considered as a tube or a cone of fire, the hollow part of which is filled with the vapour which is not inflamed. It assumes the form of a cone, because the vapour being gradually consumed as it rises, the quantity is lessened in its dimensions. The vapour is rendered of less specific gravity than the air, and so is the flame or ignited vapour, and consequently it rises upwards.

Any contrivance by which air may be more freely admitted to a body in a state of combustion makes it go on more actively. Hence the advantage of Argand's lamps which receive the air into a hollow within the flame, by which means oxygen may enter into it externally and internally. Lord Cochrane's lamps, by exposing a larger surface to admit oxygen, were an improvement upon the common lamps in the street.

If a body burn in common air, of which only one-fourth part consists of oxygen, it may be expected to burn much more actively and vividly in oxygen gas. This is the case, and a body made to burn in a phial of oxygen gas gives out a brilliant light which is dazzling to the eye. In a phial of oxygen gas if a piece of iron, as the spring of a watch, be introduced, and by any means fire be applied, it will blaze with the utmost vehemence and give out most brilliant sparks.

Some bodies have such an attraction for oxygen that, in their ordinary state, they will draw it to them and be inflamed. Of this phosphorus is an example. This

substance must be kept in water, and if a morsel be exposed to the air it will smoke and be consumed of itself. If letters be written with it on a wall or piece of board, they will be luminous in the dark until the phosphorus be consumed. When any experiments are tried with this substance, it must not be held but a very short while in the hand, as the heat of the hand would be sufficient to cause it to burst into a flame, and inflict an injury. It must speedily be put back into water, to lower its temperature, and it may again be used.

The gas which is employed to light the streets, is not combustible simply by itself, and only when mixed with oxygen; hence only that part of it which comes in contact with the air is inflamed, and the flame does not run along the interior of the pipes which convey it. The mouth of the pipe which lets out the gas to form the flame, is frequently so constructed that air is admitted to the inside of the flame as well as the outside, and it is consumed more perfectly. The combustion of the gas forms a fine watery vapour, which is dissipated in the atmosphere.

There are some places where hydrogen is formed in the bowels of the earth, accompanied with great heat, yet it does not inflame until the gas rise about the surface of the ground, when it attracts the oxygen of the air and flames arise. One of these natural laboratories of gas is at Pietra Mala, in the Apennines in Italy, between Florence and Bologna.

Most combustibles have not in ordinary circumstances such an attraction for oxygen as to inflame, until means be first taken to increase their temperature. Common coals, for instance, will not burn of themselves; but if coals be put on some coals already heated they receive an increase of temperature, and in that state attract oxygen, and combustion takes place. Logs of wood are burnt in the same way, and as the air can act only on the outside, the process is much less rapid than when it is cloven into smaller pieces. When a light is applied to pieces of paper, shavings of wood, or to flax, it instantly raises a small part to a sufficiently high temperature, and the air getting access on all sides, combustion quickly goes on.

Combustion will go on equally well, whether the oxygen be supplied from the air, or by any other way. In the making of sulphuric acid, saltpetre and sulphur are mixed together, and the saltpetre supplies oxygen to cause the sulphur to burn and give out the fumes which are attracted by water, and form sulphuric acid.

Carbon, which is the principle component part of all vegetables, is combustible, so also are hydrogen, sulphur, phosphorus, and most of the metals. Gold, silver, and mercury are incombustible. Also bodies compounded of simple combustible substances, are capable of combustion, as coals, oils, resins.

Earths are incapable of combustion. A stone may be heated in the fire, and it may be made red hot, but it will not be burnt like coals; when it is removed from the fire, it gradually gives out its heat and returns to its former state. The stones discharged from the volcano of Mount Vesuvius, heated to the utmost degree, do not inflame, but gradually give out their heat. If a sufficient degree of heat be applied to some kinds of stones, it may destroy their adhesion, they may be made to crumble down into powder, of which lime is an instance. Or the stone may be melted by the heat, which will more readily take place if certain other substances as soda, be combined with them, thus sand or flint are melted, and become glass. But earths if ever so much heated, when withdrawn from the cause of that heat, will not continue to burn of themselves, imbibing oxygen, and giving out continued streams of light and heat, but will gradually cool down, becoming every instant colder and colder, from the time that they are withdrawn from the fire by which they were heated. In this respect earths differ from metals, that

when they are melted they become vitrified, and do not on cooling return to their former state; whereas metals which have been melted, when they have cooled are the same as before. Every one has seen this in the case of melted lead, and it is the same with all other metals.

It was the theory of Lavoisier, and of the French Chemists, that combustion always arose from the combustible body absorbing oxygen, and from light and heat being given out in the process. Chemists have since discovered cases, in which combustion may take place without the presence of oxygen; and some writers have spoken of Lavoisier's theory as if it were untrue. It is true generally, and in all ordinary cases, exceptions are few which are produced by the artificial combination of prepared ingredient, in which an intense action may take place, and in the union light and heat may be evolved.

In this case, as in his theory of acids, the great French chemist undertook to lay down a general system, whilst the science was not in a sufficiently perfect state, and farther experiment has discovered cases in which his theory will not apply, of which instances have been mentioned in the preceding article. In fact, it is still too early to attempt a general theory, and all that can with strictness be said, is, that combustion takes place in all cases in which an intense and violent motion can be conceived to be communicated to the corpuscles of bodies.

Speculation, on such subjects, is, however, of the greatest utility, whilst kept in proper bounds and received merely as speculation, and not shutting up the mind against farther information and reasoning, but exciting it to farther inquiry. With this view we make an extract from Sir Richard Phillips's "Twelve Essays on the Proximate Causes of the Material Phenomena of the Universe," which cannot fail to be productive of the highest benefit in the mind of the reflecting and discerning reader.

"In considering the phenomena of combustion and light, we may observe that, when a nail has been heated by a hammer, or two pieces of wood have been rubbed together, so as with either to light a match, and with that the taper of a lamp, or the wick of a candle, or any inflammable mass, it is evident that the atomic motion thus transferred is but a portion of the blows, or the friction; yet the lamp, or the candle, or inflammable mass, will burn for hours. Whence, then, is produced this continuity of atomic motion? How is it that the effect so far exceeds the original cause?

"The answer to these questions involves the entire theories of heat, combustion, and light.

"What are the actual circumstances in which the effect takes place? The first excitement simply produced, by local application, an evolution of hydrogen gas, which, thus excited, becomes flame,—this flame produces other hydrogen, and the flame continues, but the original excitement disperses, and the effect is continued by some ill-understood power, or some re-actions of the surrounding gas. What, then, is this power which maintains the constant heat, or atomic motion, calculated to keep up the evolution of the hydrogen, and produce light?

"We know that oxygen gas is present; and that, if the evolution take place under a close vessel, the phenomena cease when the oxygen has disappeared. We know, that in the combustion of simple inflammables, whose chief constituent is the hydrogen, that aqueous vapour is created; and that water is composed of hydrogen and oxygen: the results being, hydrogen and oxygen in the form of the aqueous vapour, with carbon in form of smoke or soot. It is also known, that, when metals are highly excited by atomic motion, oxygenous atoms combine with them, and produce what are called oxides, which are heavier than the original metals.

"The most rational and generally received hypothesis, determines that gasses owe that form to the accident of their atoms being in

great relative motion, perhaps in mutual rotation; and we are forced, by numerous facts, to admit that the atoms of oxygen gas are the most active in the atmosphere. Is it not evident then, that the atoms of the oxygen, previously in *rapid motion*, have become *fixed* during the process? But, in becoming fixed, they *transferred* their motions; and atomic motion is heat, the source of which is the object of inquiry. *The fixing of the active atoms of oxygen during combustion, is therefore the cause of the heat or motion by which the combustion or evolution of hydrogen is kept up and augmented. It is the motion of the atoms of the oxygen transferred to the atoms of the inflammable gas, or to the atoms of the metal while in a state of combustion.*

"This rule holds universally. The excited gas is for the time a conductor of motion or heat; and we know that oxygen attaches itself, or is condensed in all bodies in proportion to their power of conducting motion or heat.—Hence the oxydation of metals in the atmosphere,—hence the law that positive or oxygenous electricity follows the most excited body,—hence the accumulation of oxygen, or most active atoms, on the surface of the best conductors of heat in the galvanic series, &c. &c.

"It appears too, from the experiments of Dalton, Rumford, and others, that heat evolved during the combustion of various bodies, is nearly in the exact ratio of the oxygen consumed or fixed; and the differences may probably be ascribed, either to adventitious circumstances, or to the ratio not being a simple arithmetical one.

"As motion excites the atoms of bodies by percussion or friction, after the aqueous moisture has been raised in vapour, and thereby carrying off the first actions; that then hydrogen gas is evolved, when the access and fixation of oxygen by combination increases and continues the heat. The *first* atomic motions applied to a body, therefore, are dispersed by evaporation or volatilization; but, in the *second* stage, the motions are maintained by the fixation of oxygen. It may, indeed, be suspected, that every degree of heat in dry bodies is increased by the fixation of oxygen, while at the same time *acceleration* of atomic motion, or motion added to motion, increases the intensity of the effects in a high geometrical ratio.

"The heat or atomic motion thus created by the *transfer* of the *motions* of the atoms of oxygen, produces, of course, such an excitement of the evolved hydrogen gas, as generates or propagates, by the law of the inverse ratio of the squares of the distances, those rectilinear pulsations which, acting through the coats of the eye, excite, in the retina, the perception of light; and, in the nerves of other parts of the body, the perception called heat.

"Though oxygen may, however, be the pabulum of heated hydrogen, yet, as the continuation of atomic motion is the effect produced, so whatever creates or keeps up this motion, will continue the heat or flame: or, in other words, heat will maintain heat, and motion maintain motion. Hence it is that cases exist, as in the white heat of wire, and in the fusion of glass in the exhausted receiver of an air pump, and in other instances, in which flame, or great heat, or combustion, takes place without the presence of oxygen; and hence, also, when other bodies, combined with the inflammable gas, tend to increase or decrease its intensity of motion, the same radiance of light and heat takes place, as though a smaller or larger quantity of oxygen had been fixed. The force of heat in the blow pipe is produced by the concentration of the oxygenous atoms, and by their being driven, directed, and deprived of their motion, at one point of the body acted upon. In a word, *the whole is the effect of the intense motion of atoms variously circumstanced in relation to each other*, and there are no mysteries if we cease to invent them, and examine nature by this master-key.

"The nature of oxygen, and its mode of existence, form other

questions. It is not disputed that it consists of atoms. Whether they are only of one form, or one density of different bulks,—which of these conditions is essential, and which may or does vary,—whether they are the most active and moveable atoms,—in what atoms of other gasses differ from them,—whether there is a substratum in which the oxygen moves, &c.—are points respecting which there has been a great difference of opinion amongst chemists, but which we have not room to discuss. It is sufficient, in the general developement of this theory, to ascertain, from numerous circumstances, that oxygen consists of atoms of great relative action, and, as such, is sufficient to produce the phenomena of combustion, the simultaneous evolution of hydrogen, and the other results of that process; and that, without them, the process can be carried on only by means of other intense atomic agitations, or motions.

"Detonation, or explosion, is caused whenever by the communication of sufficient atomic motion, the atoms of gas previously fixed, or combined, are reconverted into their gaseous bulk and form; and, in this conversion, part of the motion is communicated to the air, or to any solid so placed as to receive the motion; part of the oxygen of the air is, at the same time, fixed so as to augment the motion.

"Nitrous compounds explode, under fit circumstances, with violence, fixing much oxygen, and transferring and exhibiting much heat; but hydrogen, converted from a fixed to a gaseous state, and combined with carbon, explodes silently, with heat derived from the fixation of oxygen, as in tallow-gas, oil-gas, coal gas, &c. &c. all carbonates of hydrogen.

"Uncombined hydrogen explodes or expands by accession of motion with different phenomena, oxygen being fixed, and thereby exhibiting heat; and the compound being oxygenated hydrogen, or water. Nitrous compounds, thus combined with motion, and fixing oxygen, produces analogous phenomena.

"Motion transferred from the igniting body, (itself rendered so by motion,) is therefore the cause of the peculiar excitement or expansion of the hydrogen and nitrogen, and in the motions of their atoms, is absorbed; when the moving atoms of the oxygen simultaneously become fixed, and thereby transfer their motions so as to excite motion in adjoining bodies, or the perception and effect, called heat."

COMBUSTION INVISIBLE. See INVISIBLE COMBUSTION.

COMBUSTION SPONTANEOUS. See SPONTANEOUS COMBUSTION.

See also INCOMBUSTIBLE and SAFETY LAMP.

COMPTONITE. A new mineral, found in drusy cavities, in ejected masses, on Mount Vesuvius. It accurs crystallized, in straight four-sided prisms, which are usually truncated on their lateral edges, so as to form eight-sided prisms, terminated with flat summits. Transparent, or semi-transparent. Gelatinizes with acids. It is sometimes accompanied with acicular arragonite. It was first brought to this country by Lord Compton, in 1818.

CONCRETIONS (MORBID). When the soft parts of the body form solid concretions, they are said to be ossified, as these concretions consist of phosphate of lime, the same as the bones. Depositions in the cavities are generally called calculi. See URINARY CALCULI and BILE.

CONGELATION. When a fluid becomes solid, it is said to undergo congelation. The term is chiefly applied to the freezing of water. See CALORIC.

COPAL, improperly called gum copal, is a hard, shining, transparent, citron-coloured, odoriferous, concrete juice of an American tree, but which has neither the solubility in water common to gums, nor the solubility in alcohol common to resins, at least in any considerable degree. By these properties it resembles amber. It may be dissolved by digestion in linseed oil, rendered drying by quicklime, with a heat very little less than sufficient to boil or

decompose the oil. This solution, diluted with oil of turpentine, forms a beautiful transparent varnish, which, when properly applied, and slowly dried, is very hard, and very durable. This varnish is applied to snuff-boxes, tea-boards, and other utensils. It preserves and gives lustre to paintings, and greatly restores the decayed colours of old pictures, by filling up the cracks, and rendering the surfaces capable of reflecting light more uniformly.

Mr. Sheldrake has found, that camphor has a powerful action on copal; for if powdered copal be triturated with a little camphor, it softens, and becomes a coherent mass; and camphor added either to alcohol or oil of turpentine, renders it a solvent of copal. Half an ounce of camphor is sufficient for a quart of oil of turpentine, which should be of the best quality; and the copal, about the quantity of a large walnut, should be broken into very small pieces, but not reduced to a fine powder. The mixture should be set on a fire so brisk as to make the mixture boil almost immediately; and the vessel Mr. S. recommends to be of tin or other metal, strong, shaped like a wine-bottle with a long neck, and capable of holding two quarts. The mouth should be stopped with a cork, in which a notch is cut to prevent the vessel from bursting.

COPPER is a metal of a peculiar reddish-brown colour; hard, sonorous, very malleable and ductile; of considerable tenacity, and of a specific gravity from 8.6 to 8.9. At a degree of heat far below ignition, the surface of a piece of polished copper becomes covered with various ranges of prismatic colours, the red of each order being nearest the end which has been most heated; an effect which must doubtless be attributed to oxidation, the stratum of oxide being thickest where the heat is greatest, and growing gradually thinner and thinner towards the colder part. A greater degree of heat oxidizes it more rapidly, so that it contracts thin powdery scales on its surface, which may be easily rubbed off; the flame of the fuel becoming at the same time of a beautiful bluish-green colour. In a heat, nearly the same as is necessary to melt gold or silver, it melts, and exhibits a bluish-green flame; by a violent heat it boils, and is volatilized partly in the metallic state.

Copper rusts in the air; but the corroded part is very thin, and preserves the metal beneath from farther corrosion.

Copper is procured from its ore in the isle of Anglesey, in the following manner:—The ore is first broken in small pieces, and then piled up in heaps between two walls, twenty, thirty, or fifty yards in length, and covered over with flat stones, which are cemented together. The heaps are then set on fire, and the sulphur is sublimed in chimneys made for that purpose, and preserved for sale. These heaps continue three or four months burning, according to their size; some are so large (about two thousand tons in weight) as to require ten months. The ore being now reduced in weight, is washed. The water of which washing, being a solution of sulphate of copper, is precipitated by all sorts of old iron.

Pure copper is generally obtained by using the solution of sulphate of copper, which is lodged at the bottom of a bed of ore in a copper mine. This solution is drawn up and poured into pits where all kinds of old iron are thrown. The iron attracts the sulphuric acid, and is thus in time dissolved; but a thick crust of metallic copper is first precipitated on it. This is scraped off and fused; the iron is then thrown in again to precipitate more. This is repeatedly done until the iron is entirely wasted; that is, dissolved by the sulphuric acid. Precipitation of copper on iron in the large way, is also practised in Ireland and Hungary. The purest copper is always obtained in this way.

Native copper is generally found in Siberia. An entire mass has been found in the Brazils, weighing 2,666 pounds. It is now in Lisbon. A large mass was also recently found in the bed of the river

Onatanagan, in the United States of America. Notwithstanding the number of copper mines, particularly in Wales, till about the year 1730, most of the copper and brass utensils for culinary and other purposes used in this country, were imported from Hamburgh and Holland, being procured from the manufactories of Germany; even so late as the year 1750, copper tea-kettles, saucepans, and pots of all sizes were imported in large quantities; but through the persevering industry and enterprising spirit of our miners and manufacturers, these imports have become totally unnecessary. The discovery of the new copper mines in Derbyshire and Wales about the year 1773, contributed to the extension of the manufacture in this country, and it is calculated that the annual value of the exports of copper and brass is not less than 3,500,000*l*. and that the number of persons employed in the different branches and stages of these manufactures is not less than 6000. One of the richest lodes of copper that has been seen for many years past, has lately been discovered in the neighbourhood of Padstow in Cornwall; it is a fine grey ore, three feet thick, and worth from 80*l*. to 100*l*. per fathom, and is only fifteen feet below the surface of the earth, while the levels are such as to admit with ease an adit at forty fathoms. Rocks of grey ore are to be seen on the spot, of two cwt. each, and worth 10*l*. per ton. Very extensive mines of copper have lately been discovered in different parts of Ireland, which bid fair to become a source of great wealth to that country. In the county of Wicklow, there is an extent of country nearly ten miles in length, (reaching from the mountain in which gold has been found, from N. W. to S. E.) in which distinct veins of copper have been discovered. Copper ore of a very rich quality has also been discovered in the county of Wexford. The hills of Allen, of Kills, and of Killmarny, contain several valuable veins.

Copper, both in its native and combined states, likewise the ores and salts of other metals, may be gratuitously viewed at all times in the great Saloon of the British Museum; where they are arranged in glass cases, according to a generic plan, thus *Salts of Copper*, *Salts of Silver*, *Salts of Lime*, *&c. &c. &c.* The arrangement and magnificence of the whole, whilst they do honour to the science of the country, reflect great credit on the judgment of the managers. Specimens of almost all these minerals, in a state of great perfection, form also an important part of the Mineralogical and Geological collections sold by Mr. Mawe, in the Strand, London. Mr. Mawe is in possession of a piece of pure native gold, partly combined with pieces of silex. This specimen, which he found whilst travelling in the Brazils, is much worn by rolling in a river, perhaps for many ages. It contains now, as much pure gold as may be coined into 30 guineas.

Copper exists in considerable abundance in nature; it is found native; alloyed with other metals; combined with sulphur; in the state of oxide; and in that of salt. It is not unfrequently met with in the native state, sometimes crystallized in an arborescent form, and sometimes in more regular figures. Copper exists native, alloyed with gold and silver. The most abundant ores of copper are the sulphurets, and of these there are a considerable variety, exhibiting various colours, and various forms of crystals. In the state of oxide it has been found in Peru of a greenish colour mixed with white sand. In the state of salt, copper is combined with the sulphuric and carbonic acids, forming native sulphates and carbonates of copper.

In the wet way Brunswick or Friezland green is prepared by pouring a saturated solution of muriate of ammonia over copper filings or shreds in a close vessel, keeping the mixture in a warm place, and adding more of the solution from time to time, till three parts of muriate and two of copper have been used. After standing a few weeks, the pigment is to be separated from the unoxidised cop-

per, by washing through a sieve; and then it is to be well washed, and dried slowly in the shade. This green is almost always adulterated with ceruse.

This metal combines very readily with gold, silver, and mercury. It unites imperfectly with iron in the way of fusion. Tin combines with copper, at a temperature much lower than is necessary to fuse the copper alone. On this is grounded the method of tinning copper vessels. For this purpose, they are first scraped or scoured; after which they are rubbed with sal ammoniac. They are then heated, and sprinkled with powdered resin, which defends the clean surface of the copper from acquiring the slight film of oxide, that would prevent the adhesion of the tin to its surface. The melted tin is then poured in, and spread about. An extremely small quantity adheres to the copper, which may perhaps be supposed insufficient to prevent the noxious effects of the copper as perfectly as might be wished.

When tin is melted with copper, it composes the compound called bronze. In this metal the specific gravity is always greater than would be deduced by computation from the quantities and specific gravities of its component parts. The use of this hard, sonorous, and durable composition, in the fabrication of cannon, bells, statues, and other articles, are well known. Bronzes and bell-metals are not usually made of copper and tin only, but have other admixtures, consisting of lead, zinc, or arsenic, according to the motives of profit, or other inducements of the artist. But the attention of the philosopher is more particularly directed to the mixture of copper and tin, on account of its being the substance of which the speculums of reflecting telescopes are made. See SPECULUM. The ancients made cutting instruments of this alloy. A dagger analyzed by Mr. Hielm consisted of 83⅞ copper, and 16⅛ tin.

Verdegris and other combinations of copper are very destructive poisous, and will prove fatal if received into the stomach in very small quantities. They have a direct operation on the nerves and brain, as well as an effect of producing inflammation in the intestines. Sugar given in large quantities is the best antidote.

COPPERAS. The green salt sulphate of iron is so named; and also the blue salt sulphate of copper is sometimes also called copperas.

CORALS consist of nearly equal portions of carbonate of lime and animal matter.

CORK is the bark of a tree of the oak kind, very common in Spain and the other southern parts of Europe.

By the action of the nitric acid it was found to be acidified. See ACID (SUBERIC).

CORK (FOSSIL). See ASBESTOS.

CORUNDUM. This mineral may be subdivided, according to the form of its crystals, into octahedral, rhomboidal, and prismatic: of the first are automalite, ceylanite, and spinel; of the second, salamstone, sapphire, emery, and adamantine spar. The prismatic corundum is also called chrysoberyl.

COTTON. This vegetable substance is soluble in strong alkaline lees. It has a strong affinity for alumina, several metallic oxides, and tannin. Nitric acid, with heat, changes it into oxalic acid.

CREAM. The only part of milk, which rises to the surface, mixed with a little curd and serum. Heat separates the oily part, but injures its flavour.

CREAM OF TARTAR. See TARTARIC ACID.

CRICHTONITE. A mineral so called in honour of Dr. Crichton, physician to the Emperor of Russia, an eminent mineralogist. It has a velvet black colour, and crystallizes in very acute small rhomboids.

CROCUS. The yellow or saffron coloured oxides of iron and copper were formerly called crocus martis and crocus veneris. That of iron is still called crocus simply, by the workers in metal who use it.

CROSS-STONE. Harmotome, or pyramidal zeolite. Its colour is

greyish-white, passing into smoke-grey, sometimes massive, but usually crystallized. Primitive form, a double four sided pyramid, of 121° 58′ and 86° 36′. Harder than fluor spar, but not so hard as apatite. Easily frangible. Specific gravity 2.35. It fuses with intumescence and phosphorescence, into a colourless glass. Its constituents are 49 silica, 16 alumina, 18 barytes, and 15 water.

CROTON ELEUTHERIA. Cascarilla bark contains mucilage and bitter principle 864 parts, resin 688, volatile matter 72, water 48, woody fibres 3024; in 4096 parts.

CRUSTS, the bony coverings of crabs, lobsters, egg shells, and snail-shells. By Merat-Guillot, 100 parts of lobster crust, consist of 60 carbonate of lime, 14 phosphate of lime, and 26 cartilaginous matter. 100 of hen's egg shells, consist of 89.6 carbonate of lime, 5.7 phosphate of lime, 4.7 animal matter. Bones contain a larger portion of phosphate of lime; shells generally have less phosphate of lime.

CRYOLITE consists, by Klaproth, of 24 alumina, 36 soda, and 40 fluoric acid and water. It is, therefore, a soda-fluate of alumina. Vauquelin's analysis of the same mineral gives 47 acid and water, 32 soda, and 21 alumina.

CRYOPHORUS. The frost-bearer or carrier of cold, an elegant instrument invented by Dr. Wollaston, to demonstrate the relation between evaporation at low temperatures, and the production of cold.

CRYSTALS AND CRYSTALLIZATION. When fluid substances become solid they frequently assume regular polyhedral forms, which are called *crystals*, and the bodies which do so are said to be susceptible of crystallization. Many minerals are found which are thus arranged into regular forms.

To enable the particles of bodies to assume that regular form which crystals exhibit, they must have freedom of motion; and accordingly the first step is to confer on it a liquid or aeriform state, by solution in water. When common salt is dissolved in water, the particles will be too far asunder to exert reciprocal attraction; in other words, they will be more powerfully attracted by the water than by each other. If we now get rid of a portion of the water, by evaporation, the saline particles will gradually approach each other, and will aggregate according to certain laws, producing a regular solid of a cubic form. If the process be slowly conducted the particles unite with great regularity, if hurried the crystals are irregular and confused.

There are certain bodies which may be liquified by heat, and during slow cooling may be made to crystallize. This is the case with many of the metals, and with sulphur. Some other substances, when heated, readily assume the state of vapour, and during condensation present regular crystalline forms, such as iodine, benzoic acid, camphor, &c.

The hardness, brilliancy, and transparency of crystals often depend upon their containing water, which sometimes exists in them in large quantities.

Thus sulphate of soda, in the state of crystals, contains more than half its weight. This is called water of crystallization. Some salts part with it by a simple exposure to dry air, when they are said to effloresce; but there are other salts which deliquesce, or attract water from the atmosphere.

Crystallization is accelerated by introducing into the solution a nucleus, or solid body, upon which the process begins, and manufacturers often avail themselves of this circumstance.

A strong saline solution excluded from the air will frequently crystallize the instant that air is admitted, a circumstance referred to atmospheric pressure. In other cases agitation produces the same effect. The presence of light also influences the process of crystallization. Thus the crystals collected in camphor bottles in druggists' windows are always most copious upon the surface exposed to the light. Crystallized bodies affect one form in preference to others. The fluor spar of Derbyshire crystallizes in

cubes; so does common salt, nitre in the form of a six sided prism, and sulphate of magnesia in that of a four sided prism. These forms are liable to vary. Fluor spar and salt crystallize sometimes in the form of octohedra, and there are so many forms of carbonate of lime that it is difficult to select that which most commonly occurs.

Rome de Lisle referred these variations of form to certain truncations of an invariable primitive nucleus. Bergman suspected the existence of a primitive nucleus in all primitive bodies. When Hauy entered this field of inquiry he not only corroborated the opinions of Bergman, but traced with much success the laws of crystallization, and pointed out the mode of transition from primitive to secondary figures.

Those who are in the habit of cutting and polishing certain gems, have long known that they only afford smooth surfaces when broken in one direction, and that in others the fracture is irregular and uneven.

In splitting a six sided crystal of calcareous spar, we find that of the six edges of the superior base three alternate edges only will yield to the blow. The three intermediate edges resist this division. If we continue this dissection in the same direction we shall at length obtain the obtuse rhomboid.

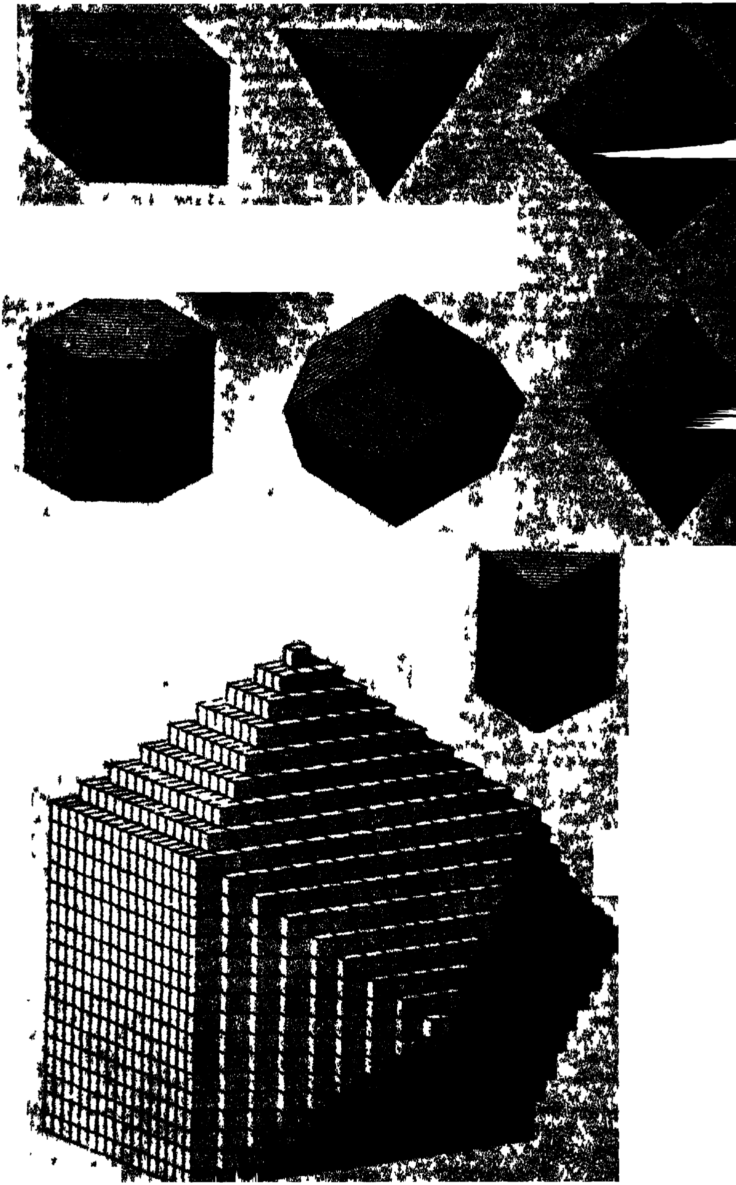
In following the method above described, Hauy obtained six primitive forms.—1. The cube, parallelopipedon, &c. 2. The tetrahedron. 3. The octohedron. 4. The hexangular prism. 5. The rhomboid dodecahedron. 6. The dodecahedron with triangular faces. See Plate.

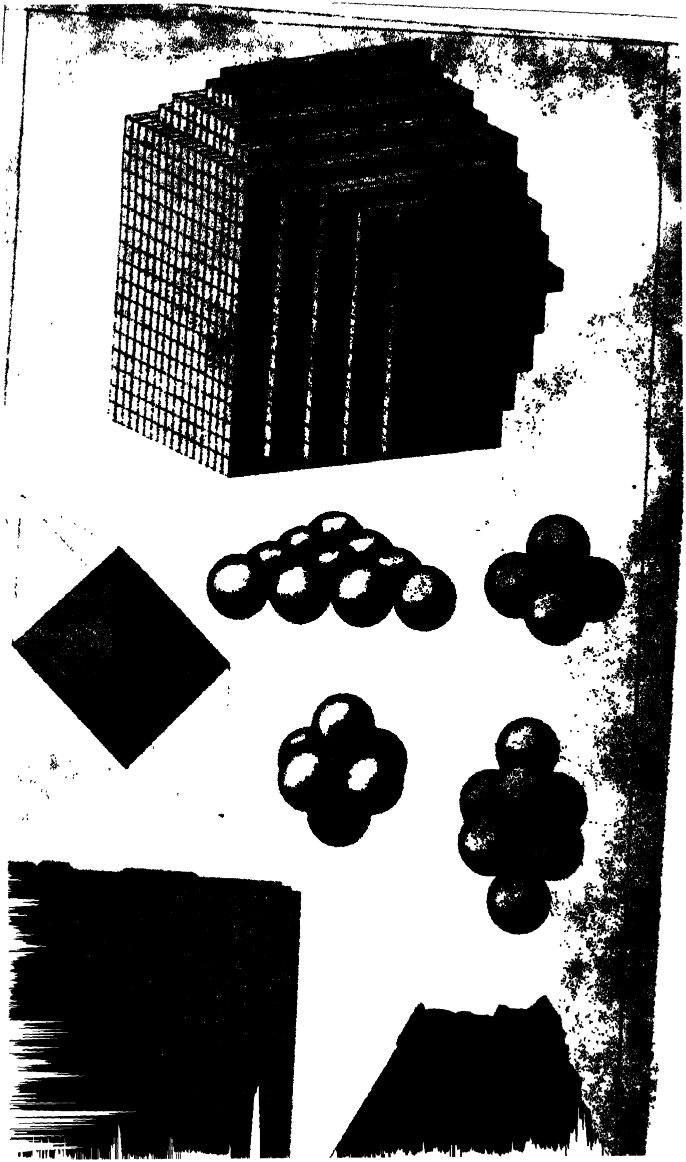
These primitive forms, by further analysis, may be reduced to three simple elements. 1. The parallelopiped, or simplest solid, having six surfaces parallel—two and two. 2. The triangular, or simplest prism, bounded by five surfaces. 3. The tetrahedron, or simplest pyramid, bounded by four surfaces.

The secondary forms are supposed to arise from decrements of particles taking place on different edges and angles of the primitive forms. Thus, a cube having a series of decreasing layers of cubic particles upon each of its six faces will become a dodecahedron if the decrement be upon the edges, but an octohedron, if upon the angles; and by irregular, intermediate, and mixed decrements an infinite variety of secondary forms would ensue.

But in crystallography there are appearances which Hauy's theory but imperfectly explains. Thus, a slice of fluor spar for instance obtained by making two successive and parallel sections, may be divided into acute rhomboids, but these are not the primitive form of the spar, because by the removal of a tetrahedron from each extremity of the rhomboid an octohedron is obtained. Thus, as the whole mass of fluor may be divided into tetrahedra and octohedra it becomes a question which of these forms is to be called primitive.

To obviate this incongruity Dr Wollaston very ingeniously proposed to consider the primitive particles as spheres which by mutual attraction have assumed that arrangement which brings them as near as possible to each other. When a number of similar balls are pressed together in the same plane, they form equilateral triangles, and if balls, so placed, were cemented together, and afterwards broken asunder the straight lines in which they would separate would form angles of 60° with each other. A single ball placed anywhere upon this stratum, would touch three of the lower balls, and the planes touching their surfaces, would then include a regular tetrahedron. A square of four balls, with a single ball resting upon the centre of each surface would form an octahedron, and upon applying two other balls at opposite sides of this octohedron, the group will represent the acute rhomboid. Thus the difficulty of the primitive form of fluor, above alluded to, is done away by assuming a sphere as the ultimate molecula. By oblate and oblong spheroids, other forms may be obtained.





The subject of crystallization has more lately engaged the attention of Mr. J. F. Daniel, and his researches have produced some singular confirmations of Dr. Wollaston's hypothesis. If an amorphous piece of alum be immersed in water, and left quietly to dissolve, at the end of three weeks we shall observe that the mass will present the forms of octohedra, and sections of octohedra, as if curved, or stamped upon its surface. The appearance is produced when the attraction of the water for the solid is nearly counter-balanced by its mechanical texture. The crystals produced by this species of dissection are highly curious from their modifications and relative positions, as the same group presents the primitive form, as well as its truncations and decrements. Other salts yield other figures, and by more complicated chemical action, as of acids upon carbonate of lime, the metals, &c. analogous results are obtained. In these cases, two circumstances are particularly remarkable, the crystals are different, and their forms vary with the different faces of the original mass. In one direction, we observe, octohedra, and sections of octohedra; in another, parallelograms of every dimension modified with certain determinate intersections.

If in either of these positions we turn the mass upon its axis, the same figures will be perceived at every quadrant of a circle; and if we suppose the planes continued, they will mutually intersect each other, and various geometrical solids will be constructed.

It is evident, then, that no theory of crystallization can be admitted, which is not founded upon such a disposition of constituent particles, as may furnish all these modifications by mere abstraction of certain individuals, without altering the original relative position of those which remain, and these conditions may be fulfilled by such an arrangement of spherical particles as would arise from the combination of an indefinite number of balls, endued with mutual attraction, and to other geometrical and where bodies afford crystals differing from the octohedral series, an analogous explanation is furnished by supposing their constituent particles to consist of oblate spheroids, whose axis bear different proportions to each other in different substances: hence we may also conclude, that the internal structure of all crystals, of the same body, is alike, however the external shape differ.

In compound bodies several substances, simple as well as compound may replace one another without any change of form taking place, provided the other constituent principles remain the same, and in the same proportions. Thus phosphorus and arsenic replace one another, so that phosphates and arseniates of the same base crystallize in exactly the same manner, when they are at the same point of saturation, and contain the same number of atoms of crystallization. The protoxides of iron, zinc, cobalt, nickel, and manganese; and also lime and magnesia, replace one another mutually, provided always, that in the combinations, which are examined, the number of atoms of water be the same. Alumine, the deutoxide of iron, and also that of manganese, may be substituted for one another. The same happens to barytes, strontian, and the oxide of lead, and also to chlorine and iodine, sulphur and selenium. These facts explain the contradiction of chemical analysis, and the geometrical measurements; for, however rigorously the analysis may have been made, one or more elements may vary.

When salts of the same form are mixed together in the same liquid, and this liquid is afterwards evaporated, these salts crystallize together, forming a part of the same crystal; and their relative proportion is determined only by the relative quantity which the liquor has had to abandon at the moment of crystallization.

CUBE ORE. Its constituents are, 31 arsenic acid, 45.5 oxide of iron, 9 oxide of copper, 4 silica, and 10.5 water, by Chenevix.

per nor silica, but 46 iron, 18 arsenic acid, 2 to 3 carbonate of lime, and 32 water.

CUPEL. A shallow earthen vessel, somewhat resembling a cup, from which it derives its name. It is made of phosphate of lime, or the residue of burned bones rammed into a mould, which gives it its figure. This vessel is used in assays wherein the precious metals are fused with lead, which becomes converted into glass, and carries the impure alloy with it. See ASSAY.

CUPELLATION. The refining of gold by scorification with lead upon the cupel, is called cupellation. See ASSAY.

CURD. The coagulum which separates from milk upon the addition of acid, or other substances. See MILK.

CYANITE, OR KYANITE. Disthene of Hauy. It consists by Klaproth, of 43 silica, 55.5 alumina, 0.50 iron, and a trace of potash. It occurs in the granite and mica slate of primitive mountains. It is cut and polished in India as an inferior sort of sapphire.

CYANOGEN. The compound base of prussic acid. See PRUSSIC ACID.

CYMOPHANE of Hauy. The Chrysoberyl.

D

DAMPS. The permanently elastic fluids which are extricated in mines, and are destructive to animal life, are called damps by the miners. The chief distinctions made by the miners, are choak-damp, which extinguishes their candles, hovers about the bottom of the mine, and consists for the most part of carbonic acid gas; and fire-damp, or hydrogen gas, which occupies the superior spaces, and does great mischief by exploding whenever it comes in contact with their lights.

DAVOURITE. A kind of red schorl found in Siberia.

DAPHNIN. The bitter principle of the plant called daphne alpina.

DATOLITE. There are two sorts of datolite, common datolite and botroidal datolite. The common datolite is of a white colour of various shades, occurs in large coarse, and small granular concretions, and crystallized. Its constituents, according to Klaproth, are silica 36.5, lime 45.5, boracic acid 24.0, water 4, with a minute portion of iron and manganese.

DATURA. An alkali supposed to be found in the datura stramonium.

DECANTATION. The action of pouring off the clearer part of a fluid by gently inclining the vessel after the grosser parts have been suffered to subside.

DECOCTION. The operation of boiling. This term is likewise used to denote the fluid itself which has been made to take up certain soluble principles by boiling. Thus we say a decoction of the bark, or other parts of vegetables, of flesh, &c.

DECOMPOSITION is now understood to imply the separation of the component parts or principles of bodies from each other.

The decomposition of bodies forms a very large part of chemical science. It seems probable, from the operations we are acquainted with, that it seldom takes place but in consequence of some combination or composition having been affected. It would be difficult to point out an instance of the separation of any of the principles of bodies which has been effected, unless in consequence of some new combination. The only exceptions seem to consist in those separations which are made by heat, and voltaic electricity. See Analysis, Gas, Metals, Ores, Salts, Mineral Waters.

DECREPITATION is the crackling noise which some salts make when suddenly heated. It arises from the parts being unequally expanded by the heat, and thereby being torn asunder, in the same

manner as glass is broken by hot water being poured upon it, or by being brought near the fire.

DELIQUESCE, to become liquid. Thus subcarbonate of potass exposed to the air attracts moisture, and becomes liquid, or deliquesces.

DELPHINIA, a new vegetable alkali, discovered in the Delphinium staphysagria.

Pure delphinia is crystalline while wet, but becomes opaque on exposure to air. Its taste is bitter and acrid. When heated it melts; and on cooling becomes hard and brittle like resin. Water dissolves a very small portion of it. Alcohol and ether dissolve it very readily. The alcoholic solution renders syrup of violets green, and restores the blue tint of litmus reddened by an acid. It forms soluble neutral salts with acids. Alkalis precipitate the delphinia in a white gelatinous state, like alumina. It forms neutral salts with the acids.

DELIQUESCENCE. The spontaneous assumption of the fluid state by certain saline substances, when left exposed to the air, in consequence of the water they attract from it.

DEPHLEGMATION. Any method by which bodies are deprived of water.

DEPHLOGISTICATED. A term of the old chemistry, implying deprived of phlogiston, or the inflammable principle, and nearly synonymous with what is now expressed by *oxygenated* or *oxidized*.

DEPHLOGISTICATED AIR. The same with oxygen gas.

DERBYSHIRE SPAR. A combination of calcareous earth with a peculiar acid called the FLUORIC, which see.

DESICCATION, making dry. It is effected in various ways. By the invention of Professor Leslie, it may be very elegantly accomplished with the air pump and sulphuric acid.

DESTRUCTIVE DISTILLATION. When organized substances, or their products, are exposed to distillation, until the whole has suffered all that the furnace can effect, the process is called destructive distillation.

DETONATION. An explosion with great noise.

DEUTOXIDE. A body containing a double proportion of oxygen.

DEW is the moisture which is insensibly deposited upon the surface of the earth. During the day, whilst the air is warm, a much larger portion of vapour is held in solution than can afterwards be retained, when the heat has diminished. Accordingly after sunset, moisture will begin to fall, and in proportion as the heat of the day is greater than that of the night, will be the quantity of dew. Hence in Egypt, and other warm climates, where the days are very hot, and the nights comparatively cold, there falls much more abundant dew than in our climate. Also in our climate, in spring and autumn, there is much heavier dew than either during the heat of summer or the cold of winter.

The cause which we have already stated, the difference of temperature between the day and night, and consequently the difference of the quantity of vapour which will be kept suspended in the air, has been the only reason which some philosophers have given, to account for the phenomenon of dew. But there is another cause, or perhaps more strictly speaking, a modification of this cause, which has no small effect; and which some philosophers have considered as the sole cause of dew, and that is the great cold of the surface of the grass, compared with the superincumbent air, and consequently the deposition of moisture from the air which comes in contact with it. As the moisture is withdrawn from the stratum of air next the ground, other moisture will descend from the next stratum, and thus the increase of dew will be continued. The phenomenon of dew is accordingly very similar to the deposition of moisture which we frequently see collected on the walls of a crowded place of worship. Both these causes have their share in producing dew, but the last is the more important, and requires particular explanation.

The difference of temperature

between the grass on the ground and the air a few feet above it, is found by the thermometer to be very considerable, as much as 10°, 15° or 20°. The effect of the coldness of the ground is known to proceed from a cause which is perfectly familiar to philosophers, the radiation of heat. The heat is radiated or emitted from the ground, and in a night when there is a clear sky, there is no return of heat radiated back again from the clouds. Accordingly, in such nights the ground will be most cooled, and, consequently, there will be a large deposition of dew from the air which comes in contact with it.

If a body be exposed to the free aspect of a serene sky, cutting off as much as possible from it every terrestrial cause of warmth, all the heat which radiates from it will be lost to it; and if what it receives from the contact of the air and the surrounding bodies do not compensate this loss, its temperature ought to sink. This is, in fact, what was first shewn by Dr. Wells, by the application of thermometers to the space immediately above bodies so exposed. It is evident that the clearness of the sky is necessary, in order that the loss of radiating caloric may be produced; for the clouds, like all other diaphenous bodies, must, according to the experiments of De Laroche, stop the caloric, which does not flow through a body which is not very warm, as we have shewn in our article on caloric. The best way of performing the experiment, is to place a thermometer at the focus of a concave metallic mirror, which is turned towards the sky. The metal radiating little heat of itself, does not communicate much to the thermometer; and as it is a good reflector it puts it in rapid communication with a larger part of the space, and accelerates the cooling. This plan was contrived by Dr. Wollaston. It is evident that the experiment must succeed better in calm weather than if the air be agitated, because, in the latter case, the contact of this fluid, renewed perpendicularly, must repair, in a great measure, the loss which the thermometer sustains. But what has already been said is sufficient to shew the numerous consequences of the principle.

Such is the cause, as Mr. Wells has shewn, of the dew and of the white frost. When bodies exposed to the aspect of a clear sky, are cooled by this aspect to a degree sufficiently low, below the temperature of the surrounding air, they produce upon their surface a precipitation of water, which is the dew itself, and if their cooling be sufficiently powerful, or if they be sufficiently cut off from all others, they freeze this water. The natives have also made ice in great abundance, in Bengal, from time immemorial, when the temperature of the air has been above 32°. According to this theory, it is evident that the dew will be deposited with greater difficulty upon bodies of which the radiation is less, as polished metals, or gravel walks, because then the air has greater advantage in warming them. Also they will be covered with dew more rarely, whilst, on the other hand, it will be seen in abundance on glass, which is a very radiating substance. It is also evident why the dew is not seen, except when the sky is serene, or the air is not agitated.

DIALLAGE, is a species of schiller spar. It is the verde di Corsica duro of which ring stones and snuff boxes are made. It is called smaragdite by Saussure. It is grass green and translucent.

DIAMOND. It appears strange, that two substances so dissimilar as charcoal and the purest diamond, should be in every thing, but external appearance, precisely the same. Newton suspected this, and Lavoisier in 1772, proved the combustibility of the diamond. In the Philosophical Transactions for 1797, is related Mr. Smithson Tennant's process for proving the identity of the two substances. He says; "It will appear from the following experiments, that the diamond consists entirely of charcoal, differing from the usual

state of that substance only by its crystallized form. From the extreme hardness of the diamond, a stronger degree of heat is required to inflame it, when exposed merely to air, than can easily be applied in close vessels, except by means of a strong burning lens; but with nitre its combustion may be effected in a moderate heat. To expose it to the action of heated nitre free from extraneous matters, a tube of gold was procured, which by having one end closed, might serve the purpose of a retort, a glass tube being adapted to the open end for collecting the gas produced. To be certain that the gold vessel was perfectly closed, and that it did not contain any unperceived impurities which could occasion the production of fixed air, some nitre was heated in it till it had become alkaline, and afterwards dissolved out by water; but the solution was perfectly free from fixed air, as it did not affect the transparency of lime-water. When the diamond was destroyed in the gold vessel by nitre, the substance which remained precipitated lime from lime-water, and with acids afforded nitrous and fixed air; and it appeared solely to consist of nitre partly decomposed, and of aerated alkali.

In order to estimate the quantity of fixed air which might be obtained from a given weight of diamonds, 2½ grs. of small diamonds were weighed with great accuracy, and being put into the tube with ½ oz. of nitre, were kept in a strong red heat for about an hour and a half. The heat being gradually increased, the nitre was in some degree rendered alkaline before the diamond began to be inflamed, by which means almost all the fixed air was retained by the alkali of the nitre. The air which came over was produced by the decomposition of the nitre, and contained so little fixed air as to occasion only a very slight precipitation from lime-water. After the tube had cooled, the alkaline matter contained in it was dissolved in water, and the whole of the diamonds were found to have been destroyed. As an acid would disengage nitrous air from this solution as well as the fixed air, the quantity of the latter could not in that manner be accurately determined.

To obviate this inconvenience, the fixed air was made to unite with calcareous earth, by pouring into the alkaline solution a sufficient quantity of a saturated solution of marble in marine acid. The vessel which contained them being closed, was left undisturbed till the precipitate had fallen to the bottom, the solution having been previously heated that it might subside more perfectly. The clear liquor being found, by means of lime-water, to be quite free from fixed air, was carefully poured off from the calcareous precipitate. The vessel used on this occasion was a glass globe, having a tube annexed to it, that the quantity of the fixed air might be more accurately measured. After as much quicksilver had been poured into the glass globe containing calcareous precipitate as was necessary to fill it, it was inverted in a vessel of the same fluid. Some marine acid being then made to pass up into it, the fixed air was expelled from the calcareous earth; and in this experiment, (in which 2½ grs. of diamonds had been employed,) occupied the space of a little more than 10.1 oz. of water. The temperature of the room when the air was measured, was at 55°, and the barometer stood at about 29.8 inches.

From another experiment made in a similar manner with one grain and a half of diamonds, the air obtained occupied the space of 6.18 oz. of water, according to which proportion, the bulk of the fixed air from 2 and ½ gr. would have been equal to 10.3 oz.

The quantity of fixed air thus produced by the diamond, does not differ much from that which, according to M. Lavoisier, might be obtained from an equal weight of charcoal.

In addition, Morveau burnt diamonds in oxygen gas, by means of a lens; and obtained no product of combustion, save carbonic acid gas. He also converted soft

iron into steel, (carburet of iron,) by cementing it with the diamond. To effect this, he secured a diamond with some filings of iron, in the centre of a piece of soft iron, and putting in an iron stopper. The whole properly enclosed in a crucible, was exposed to the heat of a blast furnace, by which the diamond disappeared, and the metal was fused, and converted into a small mass or button of cast steel.

The only perceptible difference between diamond and charcoal, (except those of form, texture, and colour,) is, that the latter contains a small portion of hydrogen; and the great inflammability of charcoal in comparison with diamond, must be owing to its want of compactness.

Fourcroy states that diamonds are usually found in an ochreous yellow earth, under rocks of grit stone; they are likewise found detached in torrents, which have carried them from their beds. They are seldom found above a certain size. The sovereigns of India reserve the largest, in order that the price of this article may not fall. Diamonds have no brilliancy when dug out of the earth, but are covered with an earthy crust.

When washed, they exhibit a sort of phosphoric or vitreous surface, which they preserve until polished. Mr. Mawe found several in the Brazils of various sizes. Some of these, of the size of filberts, may be seen at his Repository, in the Strand. Though rather opaque, they are of great use in the state of powder for polishing gems.

The value of diamonds is estimated in carats, one of which is equal to four grains, and the price of one diamond, compared with another of equal beauty, is as the square of their respective weights. Thus, suppose that the value of a cut diamond of one carat be £7., a diamond of

2 carats will be $2^2 \times 7$ . . £28.
3 . . . . . . $3^2 \times 7$ . . 63.
[illegible] . . . . $4^2 \times 7$ . . 112.
[illegible] . . . . $5^2 \times 7$ . . 175.

[illegible] diamonds are of a large [illegible]ude, this rule will not hold good, and in an article of merchandise, the value of which must depend upon the imagination, it can hardly be expected that any fixed rule should be given.

DIGESTER. The digester is an instrument invented by Mr. Papin about the beginning of the last century. It is a strong vessel of copper or iron, with a cover adapted to screw on with pieces of felt or paper interposed. A valve with a small aperture is made in the cover, the stopper of which valve may be more or less loaded, either by actual weights, or by pressure from an apparatus on the principle of the steelyard.

The purpose of this vessel is to prevent the loss of heat by evaporation. The solvent power of water when heated in this vessel is greatly increased.

Papin's digester, which the annexed cut represents, was constructed on the principle of mechanical pressure being necessary to elevate fluids to higher temperatures than their common boiling points.

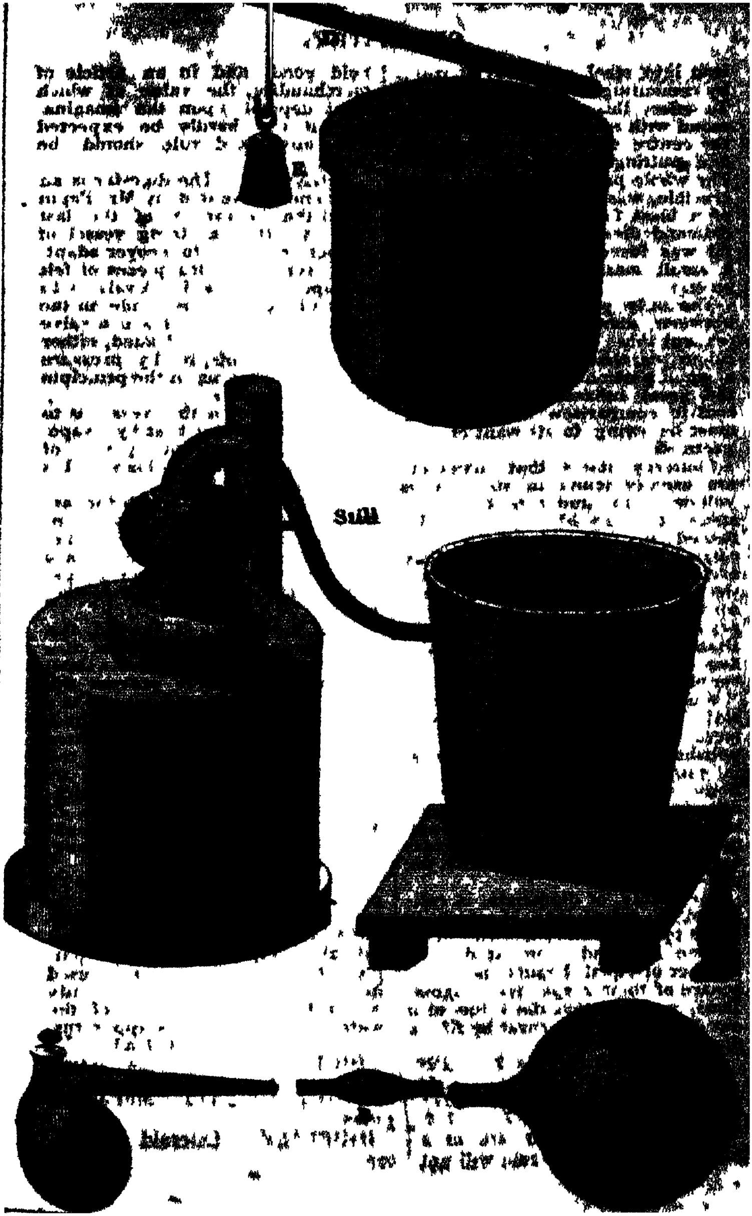
A is the boiler; B the lid, fastened down by four screws; C a valve to allow the escape of a small portion of steam, to prevent the bursting of the apparatus; D is a notched lever, on which a weight E hangs, to prevent the valve from rising by a slight expansion of the steam. The weight is heavy, according to the strength and thickness of the iron, of which the digester is formed. The whole apparatus is generally made very strong, to prevent accidents.

Animal bones are dissolved with great facility, in these digesters, in order that the gelatine contained in them, may be converted into rich soups, &c. For this purpose, they have been much used in hotels, coffee-houses, and family establishments. The heat of the water contained in this apparatus, is so intense as to melt lead.

DIGESTION. The slow action of a solvent upon any substance.

DIGESTIVE SALT. Muriate of potass.

DIOPLASE. Emerald copper ore.


Still

DIOPSIDE. A subspecies of oblique edged augite.

DIPPEL'S animal oil is obtained from the igneous decomposition of animal oil in a retort.

DISTILLATION.—Distillation is that process, by which the volatile particles of boiling fluids are vaporised, condensed, and collected in appropriate vessels.

General Observations on Distillation.—It is performed by submitting liquids to heat, in close metallic or glass vessels. The more volatile particles being in a state of vapour, ascend in the body of the still, or lower vessel, in which the liquid boils, and enter the head or capital. From thence the vapour passes into a metallic tube, called the worm, or condensing tube, which is cooled externally, by means of water contained in a large tub or wooden vessel, termed the refrigeratory. The vapour is thus condensed, (or reduced to a liquid state,) by parting with its heat through the metal to the surrounding cold water, and descends through the worm into any convenient vessel placed below. This latter part of the apparatus is named the receiver. The engraving represents the apparatus by which the process of distillation is usually carried on.

For many chemical purposes, retorts and receivers are used in distillation. The engravings represents this apparatus in a disjointed state, that its parts may be properly understood.

A is the retort, having an aperture, called the tuyere, by which liquids may be supplied without taking the parts of the apparatus asunder; B is a tube, into which the beak of the retort is to be inserted, and which communicates with the receiver C. The apparatus is to be joined together when in use.

Retorts are sometimes made of earth to resist the intense heat of fires. In the distillation of carburetted hydrogen gas, from coals, for the illumination of streets and houses, cast-iron retorts are used. Leaden retorts, as will be seen in a future page, are required for the distillation of fluoric acid.

Retorts are, however, generally made of glass, in order that the operator may see how the process is going on. This is absolutely necessary in nice and delicate experiments, as may be seen by the following one, which fully illustrates the mode of distillation by the use of retorts and receivers.

Process of Distillation, by means of the Common Still.—Put into a moderately sized still, about a pound of mint leaves (or any other herb, capable of affording an aromatic oil or essence,) with two gallons of water; and place it on a fire or furnace: lute on the head, and connect the worm with it. Now fill the refrigeratory with water; place a recipient vessel under the worm; see that the fire burns well, and that the whole apparatus is in proper order. In about half an hour, the distillation will commence, and the mint-water will trickle through the worm into the receiver, in a stream, which should never exceed the size of a thread, and it will be better not to urge the process, when conducted in this small way, beyond the degree at which the liquid drops in the most rapid manner; when it comes over more rapidly, there is danger of the fluid in the still *boiling over.* If this accident should happen, (its occurrence may be known by the liquid passing *warm* into the receiver, though the water in the *refrigeratory* is cold,) the heat of the furnace should be lessened, and the liquid which has boiled over should be set aside, and not mingled with that which has been properly distilled, as it would spoil it, and prevent it from being preserved, by becoming mouldy. When the stream ceases to exhale the smell of mint, the distillation is to be discontinued, as all the volatile particles of the leaves have already come over.

In this way, essential oils, such as pepper-mint, rue, cloves, cinnamon, anise, turpentine, juniper, and otto of roses, are distilled from herbs submitted to a strong heat with water. These oils are called essential, or volatile, to distinguish them from such as will not rise by

distillation: — accordingly, those which do not, (such as linseed, almond, castor, olive, and all animal oils,) are denominated fixed.

By distillation, all spirits and essential oils are obtained. Of the former, brandy is distilled from wine; rum from a fermented solution of sugar, or the juice of the sugar-cane; whiskey from a fermented liquor, made from potatoes, rye, oats, or barley; arrack, (an Asiatic spirit,) from rice, which has undergone fermentation similar to the above; and chili, which is made in America and Africa, from a certain fruit. The Arabs distil a spirit, which they call koumiss, from mare's milk, which has undergone fermentation. Alcohol is the spirituous ingredient in all these distilled products. The purest alcohol contains no water; its specific gravity being .837. To obtain pure alcohol, the spirit from which it is distilled, must be mixed with dry muriate of lime, which, from its affinity for water, holds possession of it, whilst the spirit ascends. The alcohol cannot be deemed pure, until the muriate of lime is left dry in the still or retort.

Compound liquors, or cordials, such as gin, hollands, &c. &c. are distilled from fermented liquors combined with oil of turpentine, juniper-berries, &c.

If the outer case in which the still is fixed, be placed on the fire, (as the still itself is in the usual mode of distilling,) it is evident, that the matter in the still can never be heated to a higher degree than 212°, the greatest heat of the surrounding water. But, in the improved apparatus, distillation is effected at a still lower temperature, (generally about 132°,) because the pressure of the atmosphere is removed from the surface of the liquid in the still by the air-pump; and, of course, from the regular application of so low a degree of heat, an agreeable flavour is secured to the distilled product.

By the great reduction in the application of heat, an important saving of fuel is effected; and the vessels, from being less exposed to the action of violent fires, will be far more durable. A less quantity of cold water, for condensing the vapour in the condensing-vessel and receiver, is required than in common distillation: this, in many cases, will be found a material convenience, particularly in some of the West India islands.

From the distillation being confined throughout the operation, to close vessels, the common loss by evaporation at the worm's end, is in this apparatus avoided, and an increase of produce is obtained. The produce of the improved apparatus has been submitted to the judgment of experienced persons, and most highly approved of. The apparatus itself may be seen at work at Mr. Tritton's manufactory, No. 63, Whitechapel, London.

It was at one time supposed, that fresh water might be obtained at sea by distillation; this plan, however, did not succeed, as the water still retained an unpleasant taste. Perhaps, if less heat were applied, on the principle of the foregoing improvement; and if the distilled water were afterwards exposed for some time to the air, this very desirable object might be attained.

DISTHENE the same as cyanite.

DOCIMASTIC ART. The art of assaying.

DOLOMITE. There are several kinds. White dolomite contains 46.5 carbonate of magnesia, 52.06 carbonate of lime, 0.25 oxide of manganese, 0.5 oxide of iron. It is found in beds in the island of Iona. A beautiful variety, found in the island of Tenedos, was used by the ancient sculptors. It consists of fine granular concretions. The brown dolomite is the magnesian limestone of Tennant. There is a columnar dolomite of a pale greyish white. Compact dolomite is of a snow-white colour. See MAGNESIAN LIMESTONE.

DRACO MITIGATUS, a name for calomel.

DRAGON'S BLOOD. Is a resin brought from the East Indies, the product of the pterocarpus.

draco, and dracæna draco. It is of a dark red colour, and imparts a fine red stain to marble. It dissolves in oils and alcohol. It contains a portion of the benzoic acid.

DRAWING SLATE. See BLACK CHALK.

DUCTILITY. That property or texture of bodies, which renders it practicable to draw them out in length, while their thickness is diminished without any actual fracture of their parts. This term is almost exclusively applied to metals.

Most authors confound the words malleability, laminability, and ductility together, and use them in a loose indiscriminate way; but they are very different. Malleability is the property of a body which enlarges one or two of its three dimensions, by a blow or pressure very suddenly applied. Laminability belongs to bodies extensible in dimension by a gradually applied pressure. And ductility is property to be attributed to such bodies as can be rendered longer and thinner by drawing them through a hole of less area than the transverse section of the body so drawn.

DYING. The art of dying consists in fixing upon cloths of various kinds any colour which may be required, in such a manner as that they shall not be easily altered by those agents to which the cloth will most probably be exposed.

As there can be no cause by which any colouring matter can adhere to any cloth, except an attraction subsisting between the two substances, it must follow, that there will be few tinging matters capable of indelibly or strongly attaching themselves by simple application.

Dying is therefore a chemical art.

The most remarkable general fact in the art of dying, consists in the different degrees of facility, with which animal and vegetable substances attract and retain colouring matter, or rather the degree of facility with which the dyer finds he can tinge them with any intended colour. The chief materials of stuff to be dyed are wool, silk, cotton and linen, of which the former two are more easily dyed than the latter. This has been usually attributed to their greater attraction to the tinging matter.

Wool is naturally so much disposed to combine with colouring matter, that it requires but little preparation for the immediate processes of dying; nothing more being required than to cleanse it, by scouring, from a fatty substance, called the yolk, which is contained in the fleece. For this purpose an alkaline liquor is necessary; but as alkalis injure the texture of the wool, a very weak solution may be used. For if more alkali were present than is sufficient to convert the yolk into soap, it would attack the wool itself. Putrid urine is therefore generally used, as being cheap, and containing a volatile alkali, which, uniting with the grease, renders it soluble in water.

Silk, when taken from the cocoon, is covered with a kind of varnish, which, because it does not easily yield either to water or alcohol, is usually said to be soluble in neither. It is therefore usual to boil the silk with an alkali, to disengage this matter. Much care is necessary in this operation, because the silk itself is easily corroded or discoloured. Fine soap is commonly used, but even this is said to be detrimental; and the white China silk, which is supposed to be prepared without soap, has a lustre superior to that of Europe. Silk loses about one-fourth of its weight by being deprived of its varnish. See BLEACHING.

The intention of the previous preparations seems to be of two kinds. The first to render the stuff or material to be dyed as clear as possible, in order that the aqueous fluid to be afterward applied, may be imbibed, and its contents adhere to the minute internal surfaces. The second is that the stuff may be rendered whiter and more capable of reflecting the light, and consequently

enabling the colouring matter to exhibit more brilliant tints.

Some of the preparations, however, though considered merely as preparative, do really constitute part of the dying processes themselves. In many instances a material is applied to the stuff, to which it adheres; and when another suitable material is applied, the result is some colour desired. Thus we might dye a piece of cotton black, by immersing it in ink; but the colour would be neither good nor durable, because the particles of precipitated matter, formed of the oxide of iron and acid of galls, are already concreted in masses too gross either to enter the cotton, or to adhere to it with any considerable degree of strength. But if the cotton be soaked in an infusion of galls, then dried, and afterward immersed in a solution of sulphate of iron (or other ferruginous salt,) the acid of galls being every where diffused through the body of the cotton, will receive the particles of oxide of iron, at the very instant of their transition from the fluid, or dissolved to the precipitated or solid state; by which means a perfect covering of the black inky matter will be applied in close contact with the surface of the most minute fibres of the cotton. This dye will therefore not only be more intense, but likewise more adherent and durable.

The French dyers, and after them the English, have given the name of *mordant* to those substances which are previously applied to piece goods, in order that they may afterward take a required tinge or dye.

It is evident, that if the mordant be universally applied over the whole of a piece of goods, and this be afterward immersed in the dye, it will receive a tinge over all its surface; but if it be applied only in parts, the dye will strike in those parts only. The former process constitutes the art of dying, properly so called; and the latter, the art of printing woollens, cottons, or linens, called calico-printing.

In the art of printing piece goods, the mordant is usually mixed with gum or starch, and applied by means of blocks or wooden engravings in relief, or from copper plates, and the colours are brought out by immersion in vessels filled with suitable compositions. Dyers call the latter fluid the bath. The art of printing affords many processes, in which the effect of mordants, both simple and compound, is exhibited. The following is taken from Berthollet.

The mordant employed for linens, intended to receive different shades of red, is prepared by dissolving in eight pounds of hot water, three pounds of alum, and one pound of acetate of lead, to which two ounces of potash, and afterwards two ounces of powdered chalk, are added.

In this mixture the sulphuric acid combines with the lead of the acetate, and falls down, because insoluble, while the argillaceous earth of the alum unites with the acetic acid disengaged from the acetate of lead. The mordant therefore consists of an argillaceous acetic salt, and the small quantities of alkali and chalk serve to neutralize any disengaged acid, which might be contained in the liquid.

Several advantages are obtained by thus changing the acid of the alum. First, the argillaceous earth is more easily disengaged from the acetic acid, in the subsequent processes, than it would have been from the sulphuric. Secondly, this weak acid does less harm when it comes to be disengaged by depriving it of its earth. And thirdly, the acetate of alumina not being crystallizable like the sulphate, does not separate, or curdle by drying, on the face of the blocks for printing, when it is mixed with gum or starch.

When the design has been impressed by transferring the mordant from the face of the wooden blocks to the cloth, it is then put into a bath of madder, with proper attention, that the whole shall be equally exposed to this fluid. Here the piece becomes of a red colour, but deeper in those places where

the mordant was applied. For some of the argillaceous earth had before quitted the acetic acid, to combine with the cloth; and this serves as an intermedium to fix the colouring matter of the madder, in the same manner as the acid of galls, in the former instance, fixed the particles of oxide of iron. With the piece in this state, the calico-printer has only therefore to avail himself of the difference between a fixed and a fugitive colour. He therefore boils the piece with bran, and spreads it on the grass. The fecula of the bran takes up part of the colour, and the action of the sun and air renders more of it combinable with the same substance.

In other cases, the elective attraction of the stuff to be dyed has a more marked agency. A very common mordant for woollens is made by dissolving alum and tartar together; neither of which is decomposed, but may be recovered by crystallization upon evaporating the liquor. Wool is found to be capable of decomposing a solution of alum, and combining with its earth; but it seems as if the presence of disengaged sulphuric acid served to injure the wool, which is rendered harsh by this method of treatment, though cottons and linens are not, which have less attraction for the earth. Wool also decomposes the alum, in a mixture of alum and tartar; but in this case there can be no disengagement of sulphuric acid, as it is immediately neutralized by the alkali of the tartar.

Metallic oxides have so great an attraction for many colouring substances, that they quit the acids in which they were dissolved, and are precipitated in combination with them. These oxides are also found by experiment to be strongly disposed to combine with animal substances; whence in many instances they serve as mordants, or the medium of union between the colouring particles and animal bodies.

The colours which the compounds of metallic oxides and colouring particles assume, then, are the product of the colour peculiar to the colouring particles, and of that peculiar to the metallic oxide.

DYKES. That the surface of the earth has been fractured since its consolidation is proved by the dislocations which rocks and strata in many situations present. It is further proved by the existence of vertical seams intersecting them, and filled with mineral matter of a different kind. When the substance found in these vertical seams is stone or earth, and they are of considerable thickness, they are called *dykes* or *faults*. When filled with metallic ores, they are generally called *veins*. Dykes or faults are frequently filled with basalt: in the northern counties they are called whin-dykes, whinstone being the provincial name for basaltic rocks. In the coal districts of Yorkshire, Derbyshire, and Staffordshire, the substance which fills dykes is commonly indurated clay. In primary and transition rocks, almost every kind of stone belonging to each class occasionally occurs, intersecting other rocks, and forming veins or dykes. The thickness of dykes varies from a few inches to twenty or thirty feet, and in some instances they exceed 300 feet. The extent to which they stretch across a country has seldom been explored, except in coal districts, where a knowledge of them is important, on account of the dislocation of the strata which they occasion.

In Cornwall, veins or dykes of granite shoot from the granite rocks into the incumbent killas or gray wacke. Granite veins have also been observed rising up into slate rocks in Scotland, and in various parts of Europe. This circumstance appears strongly in favour of the hypothesis of Dr. Hutton, that the mineral substance in dykes was formed from the melted matter of the subjacent rocks forced through the upper rocks and strata in a melted state.

The close union frequently observed between the sides of the hardest rocks and the substance of the dyke, and the circumstance of basaltic dykes charring the beds of coal near which they pass, are

also favourable to this opinion. The mineral substance of dykes is frequently harder than the rocks which they intersect, and remains after they are decomposed, forming immense walls of stone: such are met with on the western coast of Scotland, where the violence of the Atlantic Ocean has torn away the surrounding rock.

When dykes are of considerable thickness, it is observed that the mineral substances of which they are composed vary in hardness, sometimes the central parts and sometimes the sides being harder or softer than the other, and are divided by vertical seams or partings. Columnar basaltic rocks are sometimes intersected by dykes of basalt; and it is remarked that the basalt in these dykes has also a columnar structure, being composed of prisms, which are laid horizontally, or in a contrary direction to the position of the columns in the range. Those who suppose that basaltic rocks had an igneous origin, consider this circumstance as favourable to the hypothesis. The melted basalt ejected into the dyke would first begin to cool and crystallize where it was in contact with the rock on each side of it: hence the diminution of temperature, acting laterally, has given to these prisms an horizontal position. On the contrary, the columns in the range were formed by a diminution of temperature, commencing in a vertical direction, which must have been the case, whether they were formed on land or under the ocean.

If dykes have been formed by the expansive force of subterranean heat breaking the surface, and forcing melted matter into the fissure, we may expect to find rocks and strata much torn and dislocated in their vicinity; and such is generally the case. Also where a mountain rock rises abruptly, and the beds or strata are thrown into opposite directions, we may presume the existence of a dyke or fault, which has produced the irregularity we observe. More frequently, however, a series of fissures or faults, of greater or less magnitude, may be found near the declivities of very abrupt mountains: thus, on the western side of the mountainous range which separates Yorkshire from Lancashire and Cheshire, the ground near the declivities of these mountains is so much broken by a succession of faults, that it renders mining operations exceedingly uncertain and difficult.

E

EAGLE STONE. A clay ironstone.

EARTHS. The stony or pulverulent masses, which are the chief component parts of the mountains, valleys, and plains of our globe, are found to consist of a few subtances called earths. These are barytes, strontites, lime, silica, magnesia, alumina or clay, glucina, zirconia. yttria, and thorina. It is not easy to point out what are the qualities, which belong to all of these bodies, which do not, some of them, also belong to some one or other of the remaining substances in nature; yet there are properties of which the earths possess such a number as to make them a class sufficiently distinct for ordinary purposes, to make the word earths, a convenient term of arrangement.

They are incombustible; but very little soluble in water or alcohol; have little or no taste; specific gravity less than most of the metals; when pure they assume the form of a white powder; infusible, capable of combining with the acids, insipid to the taste, disposed to unite with the alkalis, sulphur or phosphorus, and each other, either by fusion or solution in water.

Between the acids, alkalis, gaseous and combustible substances, it is easy to distinguish the earths, and from the metals they are distinguished by their want of lustre, and of malleability.

This is, however, true of the

earths, only when they are in the same state as presented to us by nature, for the skill of modern chemistry has been able to decom- of these bodies, and to prove that they are metallic oxides, or oxygen united to a certain base. Thus lime has been found to consist of oxygen and a metal called calcium, barytes to consist of oxygen and a metal called barium; strontites to consist of oxygen and a metal called strontium. The metallic qualities of these bodies have however, only an evanescent existence, for if they have access to the oxygen of the air, or still more to the oxygen in water, they quickly absorb it, and reassume their earthy appearance. The class of earths therefore, will always be of important consideration with mankind. It is not unlikely that hereafter, the other earths may be decomposed, and found to be oxides in like manner. We are also far from being certain, that lime, barytes, and strontites have been reduced to their most simple and elementary particles; for, however wonderful the progress lately made, and however much it may appear to be beyond the power of science to go farther at present, future chemists may hereafter make new discoveries, and it may perhaps be found, that the elementary particles which compose many of the earths, and perhaps also of the metals, are the same; and this is the more probable, if we reason from analogy, and keep in mind what a variety of bodies are composed of the simple substances of oxygen, hydrogen, and carbon. For further particulars respecting the earths, we refer to the different articles respecting each distinct earth.

EARTHQUAKES. That fires to a very great extent, and produced by various causes, exist at different depths beneath the surface of the earth, must be evident; and recent experiments have shown, that, where the substances in which such fires occur, lie at a considerable depth, and are surmounted by a very deep and heavy superincumbent pressure, more especially when they contain large portions of elastic gases, the effects of such fires will be much greater, and more diversified, than where these circumstances are absent.

Among the most powerful and extraordinary of these effects earthquakes are to be reckoned. They are unquestionably the most dreadful of the phenomena of nature, and are not confined to those countries which, from the influence of climate, their vicinity to volcanic mountains, or any other similar cause, have been considered as more particularly subject to them, their effects having oft been felt in the British isles, although not in so extensive and calamitous a degree. Their shocks, and the eruptions of volcanoes, have been considered as modifications of the effects of one common cause; and where the agitation produced by an earthquake extends farther than there is reason to suspect a subterraneous commotion, it is probably propagated through the earth nearly in the same manner as a noise is conveyed through the air. The different hypotheses which have been imagined on this subject may be reduced to the following:—

Some naturalists have ascribed earthquakes to water, others to fire, and others, again, to air; each of these powerful agents being supposed to operate in the bowels of the earth, which they assert to abound every where with huge subterraneous caverns, veins, and canals, some filled with water, others with gaseous exhalations, and others replete with various substances, such as nitre, sulphur, bitumen, and vitriol. Each of these opinions has its advocates, who have written copiously on the subject. Dr. Lister ascribes earthquakes, as well as thunder and lightning, to the inflammable breath of the pyrites, a substantial sulphur, capable of spontaneous combustion; in a word, as Pliny had observed before him, he supposes an earthquake to be nothing more than subterraneous thunder. Dr. Woodward thinks, that the subterraneous fire, which continually raises the water from the abyss, or great reservoir, in the centre of the earth, for the supply of dew, rain, springs, and rivers, being diverted

from its ordinary course by some accidental obstruction in the pores through which it used to ascend to the surface, becomes, by such means, preternaturally assembled, in a greater quantity than usual, in one place, and thus causes a rarefaction and intumescence of the water of the abyss, throwing it into greater commotions, and at the same time making the like effort on the earth, which, being expanded on the surface of the abyss, occasions an earthquake. Mr. Mitchell supposes these phenomena to be occasioned by subterraneous fires, which, if a large quantity of water be let loose on them suddenly, may produce a vapour, the quantity and elastic force of which may fully suffice for the purpose. Again, M. Amontons, endeavours to prove, that, on the principle of the experiments made on the weight and spring of the air, a moderate degree of heat may bring that element into a state capable of causing earthquakes.

Modern electrical discoveries have thrown much light on this subject. Dr. Stukely strenuously denies that earthquakes are to be ascribed to subterraneous winds, fires, or vapours; and thinks that there is not any evidence of the cavernous structure of the earth, which such an hypothesis requires. Subterraneous vapours, he thinks, are altogether inadequate to the effects produced by earthquakes, more particularly in cases where the shock is of considerable extent: for a subterraneous power, capable of moving a surface of earth only thirty miles in diameter, must be lodged at least fifteen or twenty miles below the surface, and move an inverted cone of solid earth, whose basis is thirty miles in diameter, and axis fifteen or twenty miles, which he thinks absolutely impossible. How much more inconceivable is it, then, that any such power could have produced the earthquake of 1755, which was felt in various parts of Europe and Africa, and in the Atlantic ocean; or that which in Asia Minor, in the seventeenth year of the Christian era, destroyed thirteen great cities in one night, and shook a of earth three hundred miles in diameter. To effect this, the moving power, supposing it to have been internal fire or vapour, must have been lodged two hundred miles beneath the surface of the earth! Besides, in earthquakes, the effect is instantaneous; whereas the operation of elastic vapour, and its discharge, must be gradual, and require a long space of time; and if these be owing to explosions, they must alter the surface of the country where they happen, destroy the fountains and springs, and change the course of its rivers, —results which are contradicted by history and observation.

To these and other considerations the Doctor adds, that the strokes which ships receive during an earthquake, must be occasioned by something which can communicate motion with much greater velocity than any heaving of the earth under the sea, caused by the elasticity of generated vapours, which would merely produce a gradual swell, and not such an impulsion of the water as resembles a violent blow on the bottom of a ship, or its striking on a rock. Hence he deems the common hypothesis insufficient, and adduces several reasons to show that earthquakes are in reality electric shocks. To confirm this opinion, he notices, among other phenomena, either preceding or attending earthquakes, that the weather is usually dry and warm for some time before they happen, and that the surface of the ground is thus previously prepared for that kind of electrical vibration in which they consist; while, at the same time, in several places where they have occurred, the internal parts, at a small depth beneath the surface, were moist and boggy. Hence he infers, that they reach very little beneath the surface. That the southern regions are more subject to earthquakes than the northern, he thinks is owing to the greater warmth and dryness of the earth and air, which are qualities so necessary to electricity. It may here be noticed, that, before the earthquakes of London, in 1749, all vegetation was remarkably forward;

and it is well known, that electricity quickens vegetation. The frequent and singular appearances of boreal and austral *aurora*, and the variety of meteors by which earthquakes are preceded, indicate an electrical state of the atmosphere; and the Doctor apprehends that, in this state of the earth and air, nothing more is necessary to produce these phenomena, than the approach of a non-electric cloud, and the discharge of its contents, on any part of the earth, when in a highly electrified state. In the same way as the discharge from an excited tube occasions a commotion in the human body, so the shock produced by the discharge between the cloud and many miles in compass of solid earth, must be an earthquake, and the snap from the contact the noise attending it.

The theory of M. de St. Lazare differs from the above hypothesis, as to the electrical cause. It ascribes the production of earthquakes to the interruption of the equilibrium between the electrical matter diffused in the atmosphere, and that which belongs to the mass of our globe, and pervades its bowels. If the electrical fluid should be superabundant, as may happen from a variety of causes, its current, by the laws of motion peculiar to fluids, is carried towards those places where it is in a similar quantity; and thus it will sometimes pass from the internal parts of the globe into the atmosphere. This happening, if the equilibrium be re-established without difficulty, the current merely produces the effect of what M. de St. Lazare calls ascending thunder; but if this re-establishment be opposed by considerable and multiplied obstacles, the consequence is then an earthquake, the violence and extent of which are in exact proportion to the degree of interruption of the equilibrium, the depth of the electric matter, and the obstacles which are to be surmounted. If the electric furnace be sufficiently large and deep to give rise to the formation of a conduit or issue, the production of a volcano will follow, its successive irruptions being, according to him, nothing more in reality than electric repulsions of the substances contained in the bowels of the earth. From this reasoning he endeavours to deduce the practicability of forming a counter-earthquake, and a counter-volcano, by means of certain electrical conductors, which he describes, so as to prevent these convulsions in the bowels of the earth.

The opinion of Signior Beccaria is nearly similar; and from his hypothesis and that of Dr. Stukeley, the celebrated Priestley has endeavoured to form one still more general and more feasible. He supposes the electric fluid to be in some mode or other accumulated on one part of the surface of the earth, and, on account of the dryness of the season, not to diffuse itself readily: it may thus, as Beccaria conjectures, force its way into the higher regions of the air, forming clouds out of the vapours which float in the atmosphere, and may occasion a sudden shower, which may further promote its progress. The whole surface being thus unloaded, will, like any other conducting substance, receive a concussion, either on parting with, or on receiving, any quantity of the electric fluid. The rushing noise will likewise sweep over the whole extent of the country; and, on this supposition also, the fluid, in its discharge from the surface of the earth, will naturally follow the course of the rivers, and will take the advantage of any eminences to facilitate its ascent into the higher regions of the air.

Such are the arguments in favour of the electrical hypothesis; but, since it has been supported with so much ability, an ingenious writer, Whitehurst, in his Inquiry into the original State and Formation of the Earth, contends, that subterraneous fire, and the steam generated from it, are the true and real causes of earthquakes. When, he observes, it is considered that the expansive force of steam is to that of gunpowder as twenty-eight to one, it may be conceded that this expansive force, and the elasticity of steam, are in every way capable of producing the stupend-

ous effects attributed to these phe-

Among the most striking phenomena of earthquakes, which present a fearful assemblage of the combined effects of air, earth, fire, and water, in a state of unrestrained contention, may be noticed the following. Before the percussion a rumbling sound is heard, proceeding either from the air, or from fire, or, perhaps, from both in conjunction, forcing their way through the chasms of the earth, and endeavouring to liberate themselves: this, as has been seen, likewise happens in volcanic eruptions. Secondly, a violent agitation or heaving of the sea, sometimes preceding, and sometimes following the shock; this is also a volcanic effect. Thirdly, a spouting up of the waters to a great height—a phenomena which is common to earthquakes and volcanoes, and which cannot be readily accounted for. Fourthly, a rocking of the earth, and, occasionally, what may be termed a perpendicular rebounding: this diversity has been supposed by some naturalists to arise chiefly from the situation of the place, relatively to the subterraneous fire, which, when immediately beneath, causes the earth to rise, and when at a distance, to rock. Fifthly, earthquakes are sometimes observed to travel onward, so as to be felt in different countries at different hours of the same day. This may be accounted for by the violent shock given to the earth at one place, and communicated progressively by an undulatory motion, successively affecting different regions as it passes along, in the same way as the blow given by a stone thrown into a lake, is not perceived at the shore until some time after the first concussion. Sixthly, the shock is sometimes instantaneous, like the explosion of gunpowder, and sometimes tremulous, lasting for several minutes. The nearer to the observer the place where the shock is first given, the more instantaneous and simple it appears; while, at a greater distance, the earth seems to redouble the first blow, with a sort of vibratory continuation. Lastly, as the waters have in general so great a share in the production of earthquakes, it is not surprising that they should generally follow the breaches made by the force of fire, and appear in the great chasms opened by the earth.

The most remarkable earthquakes of ancient times are described by *Pliny*, in his Natural History. Among the most extensive and destructive of these was one by which thirteen cities in Asia Minor were swallowed up in one night. Another which succeeded, shook the greater part of Italy. But the most extraordinary one, described by him, happened during the consulate of Lucius Marcus and Sextus Julius, in the Roman province of Mutina. He relates, that two mountains felt so tremendous a shock, that they seemed to approach and retire with a most dreadful noise. They at the same time, and in the middle of the day, cast forth fire and smoke, to the dismay of the astonished spectator. By this shock several towns were destroyed, and all the animals in their vicinity killed. During the reign of Trajan, the city of Antioch was, together with a great part of the adjacent country, destroyed by an earthquake; and about three hundred years after, during the reign of Justinian, it was again destroyed, with the loss of forty thousand of its inhabitants. Lastly, after an interval of sixty years, that ill-fated city was a third time overwhelmed, with a loss of sixty thousand souls.

The earthquake which happened at Rhodes, upwards of two hundred years before the Christian era, threw down the famous Colossus, together with the arsenal, and a great part of the walls of the city. In the year 1182, the greater part of the cities of Syria, and of the kingdom of Jerusalem, were destroyed by a similar catastrophe; and in 1594, the Italian writers describe an earthquake at Puteoli, which occasioned the sea to retire two hundred yards from its former bed.

The dreadful earthquake which happened in Calabria in 1638, is

described by Father Kircher, who was at that time on his way to Sicily, to visit Mount Etna. In approaching the Gulf of Charybdis, it appeared to whirl round in such a manner as to form a vast hollow, verging to a point in the centre. On looking towards Etna, it was seen to emit large volumes of smoke, of a mountainous size, which entirely covered the whole island, and obscured from his view the very shores. This, together with the dreadful noise, and the sulphureous stench, which was strongly perceptible, filled him with apprehensions that a still more dreadful calamity was impending. The sea was agitated, covered with bubbles, and had altogether a very unusual appearance.

The Father had scarcely reached the Jesuits' college, when his ears were stunned with a horrid sound, resembling that of an infinite number of chariots driven fiercely forward, the wheels rattling, and the thongs cracking. The tract on which he stood seemed to vibrate, as if he had been in the scale of a balance which still continued to waver. The motion soon becoming more violent, he was thrown prostrate on the ground. The universal ruin around him now redoubled his amazement: the crash of falling houses, the tottering of towers, and the groans of the dying, all contributed to excite emotions of terror and despair.

The great earthquake of 1755, extended over a tract of at least four millions of square miles. It appears to have originated beneath the Atlantic ocean, the waves of which received almost as violent a concussion as the land. Its effects were even extended to the waters, in many places where the shocks were not perceptible. It pervaded the greater portions of the continents of Europe, Africa, and America; but its extreme violence was exercised on the south-western parts of the former.

Lisbon, the Portuguese capital, had already suffered greatly from an earthquake in 1531; and, since the calamity about to be described, has had three such visitations, in 1761, 1765, and 1772, which were not, however, attended by equally disastrous consequences. In the present instance, it had been remarked that, since the commencement of the year 1750, less rain had fallen than had been known in the memory of the oldest of the inhabitants, unless during the spring preceding the calamitous event. The summer had been unusually cool; and the weather fine and clear for the last forty days. At length, on the first of November, about forty minutes past nine in the morning, a most violent shock of an earthquake was felt: its duration did not exceed six seconds; but so powerful was the concussion, that it overthrew every church and convent in the city, together with the royal palace, and the magnificent opera-house adjoining to it; in short, not any building of consequence escaped. About one-fourth of the dwelling-houses were thrown down; and, at a moderate computation, thirty thousand individuals perished.

The first shock was extremely short, but was quickly succeeded by two others; and the whole, generally described as a single shock, lasted from five to seven minutes. About two hours after, fires broke out in three different parts of the city; and this new calamity prevented the digging out of the immense riches concealed beneath the ruins. From a perfect calm, a fresh gale immediately after sprang up, and occasioned the fire to rage with such fury, that in the space of three days the city was nearly reduced to ashes. Every element seemed to conspire towards its destruction; for, soon after the shock, which happened near high water, the tide rose in an instant forty feet, and at the castle of Belem, which defends the entrance of the harbour, fifty feet higher than had ever been known. Had it not subsided as suddenly, the whole city would have been submerged. A large new quay sunk to an unfathomable depth, with several hundreds of persons, not one of the bodies of whom was afterwards found. Before the sea thus came rolling in like a moun

tain, the bar was seen dry from the shore.

The great shock was succeeded about noon by another, when the walls of several houses which were still standing, were seen to open from the top to the bottom, more than a fourth of a yard, and afterwards to close again so exactly, as not to leave any signs of injury. Between the first and the eighth of November, twenty-two shocks were reckoned.

This earthquake was also felt at Oporto, Cadiz, and other parts of Europe, and equally severe in Africa. A great part of the city of Algiers was destroyed. In many places of Germany the effects of this earthquake were very perceptible; but in Holland, the agitations were still more remarkable. The agitation of the waters was also perceived in various parts of Great Britain and Ireland. At Cobham, in Surrey; Dunstall, in Suffolk; Earsy Court, in Berkshire; Eatonbridge, Kent; and many other places, the waters were variously agitated. At Eyambridge, in Derbyshire Peak, the overseer of the lead-mines, sitting in his writing-room, about eleven o'clock, felt a sudden shock, which very sensibly raised him up in his chair, and caused several pieces of plaster to drop from the sides of the room. At Shireburn Castle, Oxfordshire, a little after ten in the morning, a very strange motion was observed in the water of a moat which encompasses the building. Similar instances occured at Loch Lomond and Loch Ness, in Scotland. At Kinsale, in Ireland; and all along the coast to the westward, many similar phenomena were observed. Shocks were also perceived in several parts of France, as at Bayonne, Bourdeaux, and Lyons; and commotions of the waters were observed at Angoulesme, Belleville, Havre de Grace, &c. but not attended with any remarkable circumstances.

At sea the shocks of this earthquake were felt most violently. Among other catastrophes, the captain of the Nancy frigate, off St. Lucar, felt his ship so violently shaken, that he thought she had struck the ground; but, on heaving the lead, found she was in a great depth of water.

The earthquakes in Sicily, and in the two Calabrias, began on the 5th of February, 1783, and continued until the latter end of the May following, doing infinite damage, and exhibiting at Messina, in the parts of Sicily nearest to the continent, and in the two Calabrias, a variety of phenomena. The earth was in a constant tremor, and its motions were various, being either vortical, or whirling round, horizontal, or oscillatory, that is, by pulsations or beatings, from the bottom upwards. There were many openings and cracks in the earth; and several hills had been lowered, while others were quite level. In the plains, the chasms were so deep, that many roads were rendered impassable. Huge mountains were severed, and portions of them driven into the vallies, which were thus filled up. The total amount of the mortality occasioned by these earthquakes, in Sicily and the two Calabrias, was, agreeably to the official returns, thirty-two thousand three hundred and sixty-seven; but Sir William Hamilton thought it still greater, and carries his estimate to forty thousand, including foreigners.

The shocks felt since the commencement of these formidable earthquakes, amounted to several hundreds; and amongst the most violent may be reckoned the one which happened on the 28th of March. It affected most of the higher parts of Upper Calabria, and the inferior part of Lower Calabria, being equally tremendous with the first. Indeed these shocks were the only ones sensibly felt in the capital, Naples. With relation to the former, two singular phenomena are recorded: at the distance of about three miles from the ruined city of Oppido, in Upper Calabria, was a hill, having a sandy and clayey soil, nearly four hundred feet in height, and nearly nine hundred feet in circumference at its base. This hill

is said to have been carried to the distance of about four miles from the spot where it stood, into a plain called Campo di Bassano. At the same time, the hill on which the city of Oppido stood, and which extended about three miles, divided into two parts: being situated between two rivers, its ruins filled up the valley, and stopped their course, forming two large lakes, which augmented daily.

Sir William Hamilton, from the limited boundaries of these earthquakes, was persuaded that they were caused by some great operation of nature, of a volcanic kind. To ascertain this, he began his tour by visiting the parts of the coasts of the two Calabrias which had suffered most from this severe visitation. He every where came to ruined towns and houses, the inhabitants of which were in sheds, many of them built on such insalubrious spots that an epidemy had ensued. These unfortunate people agreed that every shock they had felt, seemed to come with a rumbling noise from the westward, beginning usually with the horizontal motion, and ending with the vortical, or whirling motion, which last had ruined most of the buildings. It had also been generally observed, that, before a shock, the clouds seemed to be fixed and motionless; and that, after a heavy shower of rain, a shock quickly followed. By the violence of some of the shocks, many persons had been thrown down; and several of the peasants described the motion of the earth as so violent, that the tops of the largest trees almost touched the ground from side to side. It had been stated, in the reports made to government, that two tenements, named Macini and Vaticano, had, by the effect of the earthquake, changed their situation. In this fact Sir William agrees, and he accounts for it in the following manner:—They were situated in a valley surrounded by high grounds, and the surface of the earth, which had been removed, had probably been long undermined by the little rivulets which flow from the mountains, and were in full view on the bare spot the tenements had deserted. He conjectures besides, that, the earthquake having opened some depositions of rain-water in the clayey hills which surround the valley, the water, mixing with the loose soil, and taking its course suddenly through the undermined surface, had lifted it up, together with the large olive and mulberry trees, and a thatched cottage, floating the entire piece of ground, with all its vegetation, about a mile down the valley, where he saw it, with most of the trees erect, These two tenements occupied a space of ground about a mile in length, and half a mile in breadth. There were in the vicinity several deep cracks in the earth, not one of which was then more than a foot in breadth; but Sir William was credibly assured, that, during the earthquake, one had opened wide, and had swallowed up an ox, and nearly a hundred goats.

The force of the earthquakes, although very violent at Messina, and at Reggio on the opposite side of the strait, was not to be compared to that which was felt in the plain. In the former city the mortality did not exceed seven hundred, of a population of thirty thousand. Sir William concludes by remarking, that the local earthquakes here described, appear to have been caused by the same kind of matter as that which gave birth to the Æolian or Lipari islands. He conjectures that an opening may have been made at the bottom of the sea, most probably between Stromboli and Upper Calabria; for from that quarter, it was on all hands agreed, the subterraneous noises seemed to proceed. He adds, that the foundation of a new island, or volcano, may have been laid, although it may be ages, which to nature are but moments, before it shall be completed, and appear above the surface of the sea.

Count Francesco Ippolito, in speaking of the last great shock of the 28th of March, as it affected the Calabrian territory, is persuaded that it arose from an inter-

nal fire in the bowels of the earth, as it took place precisely in the mountains which cross the neck of the peninsula, formed by the two rivers, the Lameto and the Corace, the former of which flows into the Gulf of St. Euphemia, and the latter into the Ionian Sea. All the phenomena it displayed, made this evident.

South America has been at all times very subject to earthquakes; and it is remarkable, that the city of Lima, the capital of Peru, situated in about twelve degrees of south latitude, although scarcely ever visited by tempests, and equally unacquainted with rain as with thunder and lightning, has been singularly exposed to their fury.

Since the establishment of the Spaniards in Peru, the first earthquake in this capital happened in 1582; but the damage it did was much less considerable than that of some of those which succeeded. Lima has been often visited by violent shocks, and in 1609, a third convulsion threw down many houses; and in 1630, so much damage was done by an earthquake, that, in acknowledgment of the city not having been entirely demolished, a festival is also on that day annually celebrated. In 1654, the most stately edifices in Lima, and a great number of houses, were destroyed by a similar event; but the inhabitants having had timely presages, withdrew themselves from their houses, insomuch that few perished. In 1678, another dreadful concussion took place.

Among the most tremendous earthquakes with which the Peruvian capital has been visited, may be reckoned that which happened on the 28th of October, 1687. The first shock was at four in the morning, when several of the finest public buildings and houses were destroyed, with the loss of many lives. During the second shock the sea retired considerably, and then returned in mountainous waves, entirely overwhelming Callao, the sea-port of Lima, distant five miles, as well as the adjacent country, together with the wretched inhabitants. From that time six other earthquakes were felt at Lima, prior to that of 1746, which likewise happened on the 28th of October, at half past ten at night. At length the horrible effects of the first shock ceased; but the tranquillity was of short duration, the concussions swiftly succeeding each other. The sea, as is usual on such occasions, receding to a considerable distance, returned in mountainous waves, foaming with the violence of the agitation, and suddenly buried Callao and the neighbouring country in its flood. This terrible inundation extended, as well as the earthquake, to other parts of the coast, and several towns underwent the fate of Lima. The number of persons who perished in that capital, within two days after the earthquake commenced, on an estimate of the bodies found, amounted to thirteen hundred.

The earthquake of Jamaica, in 1692, was one of the most dreadful history has had to record. In the space of two minutes it destroyed the town of Port Royal, and sunk the houses in a gulf forty fathoms deep. It was attended with a hollow rumbling noise, like that of thunder. In less than a minute, the greater part of the houses on one side of the streets, were, with their inhabitants, sunk beneath the water, while those on the other side were thrown into heaps, the sandy soil on which they were built rising like the waves of the sea, and suddenly overthrowing them on its subsidence. The fissures in the earth were in some places so great, that one of the streets appeared of more than twice its original breadth. In many places the earth opened and closed again; and this agitation continued for a considerable time. Several hundreds of these openings were to be seen at the same moment: in some of them the wretched inhabitants were swallowed up; while in others, the earth suddenly closing, caught them by the middle, and thus crushed them to death. Other openings, still more dreadful, swallowed up entire streets; while others, again, spouted up cataracts

of water, drowning those whom the earthquake had spared.

In 1812, Venezuela was visited by one of these tremendous earthquakes. During a minute and fifteen seconds the earth was convulsed in every direction, and nearly twenty thousand persons fell victims. The towns of Caraccas, La Guayra, Mayquetia, Merida, and Sanfelipe, were totally destroyed. Barquisimeto, Valencia, La Vittoria, and others, suffered considerably.

A remarkable instance of the connection of earthquakes with volcanoes is recorded in Raffles' History of Java. Papandayang was formerly one of the largest volcanoes in that island; but in 1772, the greatest part of it was, after a short but severe combustion, swallowed up by a dreadful convulsion of the earth. This event was preceded by an uncommonly luminous cloud, by which the mountain was completely enveloped, and which so terrified the inhabitants, dwelling at the foot and on its declivities, that they betook themselves to flight. Before they could all save themselves, however, the mountain began to give way, and the greater part of it actually *fell in* and disappeared in the earth. At the same time, a tremendous noise was heard, resembling the discharge of the heaviest cannon; while the immense quantities of volcanic substances which were thrown out, and spread in every direction, propagated the effects of the explosion through the space of many miles.

The very interesting work of Governor Raffles, contains several curious and novel details relative to volcanic phenomena, a sketch of which is here introduced, on account of their intimate connection with the subterraneous operations of nature, in the production of earthquakes. It merits the attention of the philosophical particularly, as being intimately connected with volcanic erruption, and explosion of water and mud.

There are in Java thirty-eight large mountains, which, although they differ from each other in external figure, agree in the general attribute of volcanoes, by their having a broad base, which gradually verges towards the summit, in the form of a cone. One of these is named Tankuban-Prahu, on account of its resembling, at a distance, a boat turned upside down; and forms a vast truncated cone. Its base extends to a considerable distance, and it is not only one of the largest mountains in the island, but a most interesting volcano. Although it has not for many ages had any violent eruption, as is evident from the progress of vegetation, and from the depth of black mould which covers its sides, its interior has continued in a state of uninterrupted activity. Its crater is large, and has, in general, the shape of a funnel, but with its sides very irregular: the brim, or margin, which bounds it at the top, has also different degrees of elevation, rising and descending along the whole course of its circumference. This may be estimated at a mile and a half; and the perpendicular depth on the south-side, where it is very steep, is at least two hundred and fifty feet: towards the west it rises considerably higher. The bottom of the crater has a diameter of nine hundred feet, but is not regular in its form, which depends on the meeting of the sides below.

Near the centre it contains an irregular oval lake, or collection of water, the greatest diameter of which is nearly three hundred feet. The water being white, it exhibits the appearance of a lake of milk, boiling with a perpetual discharge of large bubbles, occasioned by the development of fixed air. Towards its eastern extremity are the remaining outlets of the subterraneous fires, consisting of several apertures, from which an uninterrupted discharge of sulphureous vapours takes place. These vapours rush out with incredible force, with violent subterraneous noises, resembling the boiling of an immense cauldron in the bowels of the mountain. When at the bottom, the force of the impression made on the spectator by this grand and terrific scene, is

increased by the recollection of the dangers he had to encounter in the descent; while the extent of the crater, and the remains of the former explosions, afford an indescribable enjoyment, and fill his mind with the most awful satisfaction.

The explosions of mud, called by the natives *blédeg*, are a great curiosity. This volcanic phenomenon is in the centre of a limestone district, and is first discovered, on approaching it from a distance, by a large volume of smoke, which rises and disappears at intervals of a few seconds, and resembles the vapours arising from a violent surf. A dull noise, like that of thunder, is at the same time heard; and, on a nearer approach, when the vision is no longer impeded by the smoke, a large hemispherical mass is observed, consisting of black earth, mixed with water, about sixteen feet in diameter, rising up to the height of twenty or thirty feet in a perfectly regular manner, and, as it were, pushed up by a force beneath. This mass suddenly explodes with a dull noise, and scatters, in every direction, a volume of black mud. After an interval of a few seconds, the hemispherical body of earth or mud again rises and explodes. In the same manner this volcanic ebullition goes on without interruption, throwing up a globular body of mud, and dispersing it with violence through the neighbouring plain. The spot where the ebullition occurs is nearly circular, and perfectly level, and is entirely covered with the earthy particles, impregnated with salt water, which are thrown up from below.

The tremendous violence with which nature marks the operations of volcanoes in these regions, will be best exemplified by the following details of the extraordinary and wide-spreading phenomena which accompanied the eruption of the Tomboro mountain, in the island of Sumbawa, one of the Javanese cluster. This eruption, which happened in April, 1815, was sensibly felt over the whole of the Molucca islands, over Java, and over a considerable portion of Celebes, Sumatra, and Borneo, to a circumference of a thousand statute miles from its centre, by tremulous motions and loud explosions; while, within the range of its more immediate activity, embracing a space of three hundred miles around it, it produced the most astonishing effects, and excited the most alarming apprehensions. On Java, at the distance of three hundred miles, it seemed to be awfully present. The sky was overcast at noon-day with a cloud of ashes; the sun was enveloped in an atmosphere, the "palpable" density of which it was unable to penetrate; showers of ashes covered the houses, the streets, and the fields, to the depth of several inches; and, amid this darkness, explosions were heard at intervals, like the report of artillery, or the noise of distant thunder. The first explosions were heard at Java, on the evening of the 5th of April, and continued until the following day, when the sun became obscured, and appeared to be enveloped in a fog. On the evening of the 10th, the eruptions, however, were more loud and more frequent; ashes fell in abundance; the sun was nearly obscured; and in several parts of the island a TREMULOUS MOTION OF THE EARTH was felt. On the following day, the explosions were so tremendous as to shake the houses perceptibly in the more eastern districts.

In describing the great earthquake at Cumana, M. Humboldt says, that from October 28, to the 3rd of November, a reddish fog was thicker than it had yet been. The heat of the night seemed stifling, though the thermometer rose only to 91°. The breeze, which generally cooled the air from eight or nine o'clock in the evening, was no longer felt. The atmosphere appeared as if it were on fire. The ground, parched and dusty, was cracked on every side. On the fourth of November, about two in the afternoon, large clouds of an extraordinary blackness, enveloped the high mountains of the

Brigantine and Tataraqual. They extended, by degrees, as far as the zenith. About four in the afternoon, thunder was heard, over our heads, but at an immense height, without rolling, and with a hoarse and often interrupted sound. At the moment of the strongest electric explosion, at 4 h. 12 m. there were two shocks of an earthquake, which followed at fifteen seconds distance from each other. The people in the streets filled the air with their cries. M. Bonpland, who was leaning over a table, examining plants, was almost thrown on the floor. I felt this shock very strongly, though I was lying in a hammock. Its direction was from north to south, which is rare at Cumana. Slaves, who were drawing water from a well, more than eighteen or twenty feet deep, near the river Manzanares, heard a noise like the explosion of a strong charge of gunpowder. The noise seemed to come from the bottom of the well. About nine in the evening there was another shock, attended with a subterraneous noise. The earthquake of the 4th of November, the first I had felt, made so much the more lively an impression on me, as it was accompanied with remarkable meteorological variations. It was, moreover, a real lifting-up, and not a shock by undulations. I did not then imagine, that, after a long abode on the table-lands of Quito, and the coasts of Peru, I should become almost as familiar with the abrupt movements of the ground, as we are in Europe with the of thunder. We did not think of rising at night, in the city of Quito, when subterraneous rumblings (*bramidos*), which seem always to come from the volcano of Pichincha, announced (two or three, and sometimes seven or eight minutes before) the shock, the force of which is seldom in proportion to the intensity of the noise. In 1784, the inhabitants of Mexico were accustomed to hear the thunder roll beneath their feet, as it is heard by us in the region of the clouds. In 1822, the tremendous earthquake took place in Syria, by which whole cities were destroyed, and 20,000 persons perished in a few seconds.

EARTHENWARE. See POTTERY.

EAU DE LUCE consists chiefly of the essential oil of amber and the volatile alkali.

EBULLITION is that salient motion which fluids exhibit when strongly heated.

Boiling is the term generally applied to this motion, when it takes place under the common pressure of the atmosphere. When solid bodies are heated, they attain high temperatures, without the escape of any of their particles; this is not the case with fluids; for, having arrived at certain heats, they are rapidly formed into vapour, or steam; which, overcoming the pressure of the air, ascends, and robs the fluid of a portion of heat sufficient to preserve itself in the elastic form.

The process of boiling may easily be exemplified, by half-filling a Florence flask with water, and suspending it over a lamp. Bubbles of atmospheric air, with which the water was previously impregnated, will first appear at the bottom of the flask, and, from their levity, arise to the surface, where they will be discharged into the atmosphere. As the heat is increased, *bubbles of vapour*, are formed; these also rise to the surface; they will do so more frequently, and with increased agitation and violence, as the process goes on.

By these means, the fluid under operation cannot attain a higher nperature than that in which ebullition is exhibited; for, although the boiling water is equally heated, at one instant of time, still an immediate addition of heat forms the lower stratum into elastic vapour, which, from its levity, rises to the surface, as a bubble, and there explodes, carrying off with it the superabundant portion of heat which it had just received.

Hence, it is useless expense and labour to add fuel to a fire on which a liquid already boils, in order to make it boil faster, or to bring it to a higher temperature. For as long as there is no extraordinary pressure, the fluid cannot become hotter

than its boiling point permits: for example, the hottest fire cannot render water, in an open vessel, hotter than 212°; the attempt to give it a further heat would prove abortive, for it could only serve to dissipate the water in the form of steam.

Ebullition, therefore, properly speaking, is the motion of fluids when they evaporate rapidly by being submitted to heat.

It happens, however, that all fluids do not boil at the same heat; as may be known by immersing a thermometer in them at the time: six ounces of ether would be completely evaporated, or boiled away if placed over a fire, before two ounces of water could enter into a state of ebullition: and six ounces of water would disappear in the same manner, before two ounces of linseed oil could be made to boil. The following table shews the boiling points, or temperatures, of various liquids, of Fahrenheit's thermometer.

Sulphuric ether boils at		98°
Liquid ammonia	——	140°
Alcohol	——	176°
Water	——	212°
Nitric acid . .	——	248°
Sulphuric acid .	——	540°
Phosphorus . .	——	554°
Oil of turpentine	——	560°
Sulphur . . .	——	570°
Linseed oil . .	——	600°
Mercury . . .	——	660°

Boiling is so common an operation, that it is almost needless to describe its use. It is well known, that water in its cold state has not the power of solution or digestion that boiling water has. By means of boiling water, animal and vegetable substances are in part dissolved, before they enter the stomach to be further digested. Another important use of boiling is the purification of water from earthy salts. The Thames and New River waters always deposit a crust on the inside of tea-kettles and steam-engine boilers; consequently the water boiled in them is purified. In rainy weather, so much earth is washed into rivers, that it is absolutely necessary to boil the water, before it is drank. In China and Holland, in consequence of the passage of the rivers over a clayey soil, the inhabitants are accustomed to purify all the water they use, by boiling. When water is boiled, it is insipid for a considerable time, from the loss of atmospheric air with which it had previously been combined; but if permitted to stand in an open vessel it will soon again be impregnated by it, and recover its ordinary taste.

Fluids boil at different temperatures, according as they are affected by pressure of the atmosphere, or of any other body: and less or more heat is required for their ebullition, according as the body which presses on them, is light or heavy.

If the thermometer were plunged into a vessel filled with pure water, and this water were made to boil by means of fire, the mercury of the thermometer would always keep itself at the same degree during the whole time of boiling. It is easy to try this, and the phenomenon gives us a fixed term of our thermometrical scale. But if the experiment be repeated different days, when the barometer indicates pressures of the atmosphere sensibly different, it is found, that this term is not exactly the same; it is higher when the pressure of the atmosphere is greater, and lower when it is less. Accordingly, it must be observed, that if the pressure diminish farther, the degree of ebullition will sink more and more: this indication may be verified by ascending mountains, and there boiling water at different altitudes; for as the barometer falls in proportion to the ascent, in performing this experiment, it is found that the thing really takes place, as we had foreseen. If we have marked by the number 212°, the term of boiling water at the surface of the earth, when the barometer marks the mean pressure of the atmosphere at the level of the sea; when we shall have afterwards ascended, so that the barometer shall only mark a less height, the water will begin to boil when the thermometer will mark less than 212 degrees, and generally there will be a constant correspondence between the sinking of the degree and the indica

tion of the barometer. The relation of these two phenomena may be determined by experiments made at different heights; and the degree at which water will boil, may be determined from the height of the barometer; or the height of the barometer may be determined from the degree at which water has boiled. We may arrive at results still more precise, and much more general, by another process, which does not require any change of place. When the pressure of the barometer does not differ much from 28 inches; an augmentation, or a diminution of the pressure of an inch, corresponds exactly with 1° in the centesimal division in the temperature of boiling water; that is to say, for instance, that if the pressure, instead of being at 28 inches, is at 27, the term of ebullition, instead of being at 100°, will correspond with 99°, so that if it be wished to regulate a thermometer in this circumstance, and there be marked in it the point of ebullition, as well as that of melting ice, the interval must be divided into 99 parts to have centesimal degrees, or that the thermometer may indicate 100° in boiling water, when the barometer shall be at 28 inches. The contrary would happen if the barometer were at 29 inches; for then the term of ebullitio would be at 101°, and the interval between this point and that of melting ice must be divided into 101 parts.

It will be recollected, that in order to make experiments with exactness, use must be made of distilled water, or of rain water, or of snow water, perfectly pure; for almost all river and spring waters contain, in combination with them in solution, salts which retard their boiling.

When water has been made to boil upon the mountains, there happens then a phenomenon of which it is proper to be forewarned: it is, that in proportion to the ascent, it becomes more difficult to boil water, although, nevertheless, it may boil at degrees of the thermometer much lower than on the surface of the earth: this arises, then, from the difficulty of keeping up a fire, which may cause the water to boil. The air in proportion to the ascent becomes rarer, that is to say, it has less mass in proportion to the same volume. Now one of the constituent principles of air, which is named oxygen, is the only and essential element of combustion; or rather the phenomenon which we call combustion, is nothing else but the combination which is made of this principle with combustible bodies, which is proved by the chemists in a satisfactory manner. When we blow the fire, we merely direct upon the combustible bodies a greater mass of this oxygen contained in the air. Let us come now to the application: since in rising in the atmosphere the air becomes rarer, it is necessary to blow to bring a greater volume upon the same point, that there may be in reality the same mass of oxygen; consequently, with an equal volume, it must furnish the fire with an element less active, and the difficulty of keeping it up must augment with the elevation.

After what we have said respecting the changeableness of the temperature necessary for the ebullition of water, it might from analogy be expected, that the term of melting ice, which is at the other extremity of the scale, would in like manner change with the pressure of the atmosphere: but the most accurate experiments have never shewn the slightest variation even on the highest mountains, even in a space entirely void of air. It is therefore only necessary to distinguish between the temperature of melting ice, which is fixed, and that of congelation, which is not always so.

ECHINI. Calcareous petrefactions of the echinus, or sea hedge-hog.

EDULCORATE. To become sweet.

EFFERVESCENCE is the commotion produced in fluids by some part of the mass suddenly taking the elastic form, and escaping in numerous bubbles.

EFFLORESCENCE is the effect which takes place when bodies spontaneously become converted into a dry powder. It is almost always occasioned by the loss of the

water of crystallization in saline bodies. Natron is an example of efflorescence, when it appears as a salt on the surface of the ground. Alum effloresces in the same way.

EGGS. The eggs of hens, and of birds in general, are composed of several distinct substances. 1. The shell, or external coating, which is composed of carbonate of lime .72, phosphate of lime .02, gelatine .03. The remaining .23 are perhaps water. 2. A thin white and strong membrane, possessing the usual characters of animal substances. 3. The white of the egg, for which see ALBUMEN. 4. The yolk, which appears to consist of an oil, of the nature of fat oils, united with a portion of serous matter, sufficient to render it diffusible in cold water, in the form of an emulsion, and concrescible by heat. Yolk of egg is used as the medium for rendering resins and oils diffusible in water.

EISENRAHM. Red; scaly iron ore. Brown; scaly manganese ore.

ELAIN. The oily principle of solid fats.

ELASTICITY, the principle by which the same matter is made to fill a larger space, and thereby exhibit considerable force. The cause of this principle, and the origin of its force have in all ages been a subject of discussion among metaphysicians and philosophers. It has been adduced as a proof of a vacuum, because the same atoms could not fill a larger space without interstices; and as a proof of the existence of a principle of repulsion, because the atoms appeared to separate without any other cause than one of repulsion. But M. Lavoisier having taught the principle, that heat itself was a peculiar matter; this matter of heat or *caloric* was assumed as sufficient to explain the phenomena by its introduction between the atoms of the expanded body, particularly as cases of expansion were always accompanied by heat. This theory has been satisfactory to all who gave credit to the existence of the matter of heat; but as the existence of such matter has been treated by many chemists as chimerical, the true cause of elasticity remains in dispute. A theory has, however, been recently published by Sir R. Phillips, in connection with his general system, which ascribes all phenomena to forces necessarily generated by the multiplication of matter into motion, and the force evinced during the expansion of elastic bodies, the matter being the same, he ascribes to an increased velocity of the atoms. He adopts the doctrine that heat, in all cases, is nothing more than atoms in intense motion; as for example, if a piece of iron be struck with a hammer he considers the momentum of the hammer as transferred to the piece of iron, the minute atoms of which radiate with a force equal to the momentum of the hammer; and to prove that no motion is lost during such percussion, he states that if a tile were struck by the hammer, the expansion of its parts would exhibit nearly the total momentum of the hammer; while in the other case, as the parts of the iron do not fly about like those of the tile, the momentum is then diffused by the radiation of the minute atoms of the iron. He has then calculated the accumulated momenta of such a number of the strokes of the hammer as usually confers upon it a red heat, and finds that the atoms, would at such time, acquire a velocity equal to that of light. In experimental proof, that such radiation is taking place from the iron, he adduces the phenomena of cooling processes, as when water is placed upon a piece of iron so heated, its atoms are instantly radiated, and the motion of the iron being *transferred* to them, it simultaneously becomes cool. But, says he, the radiation in no such case takes place in void space, but the atoms, as in the above case of water, radiate into a space already occupied with atoms, and infringing against these are deflected again and again, till by continued deflections they are turned into circles of rotation, and in that condition occupy a space with their power, which we call gas, and the space so occupied will be larger or smaller in proportion to the momentum, or heat transferred to the atoms. Power is, therefore,

on this theory co-extensive with gaseous existence; and of course, power and heat are acquired by whatever re-fixes these atoms, and acquires their momenta, as animals in respiring, bodies in combustion, bodies in contact during the condensation of gas, &c. &c. The novelty and boldness of these doctrines, though worthy of the consideration of philosophers, and proper objects for exhibition in this place, are, nevertheless, such as render it improper for us to insist upon them beyond their own intrinsic claims.

This theory of gaseous elasticity will be found on comparison to be very different from that of Descartes, copied by Davy. It assigns orbits to the atoms, and what is more explains the probable cause of the orbicular motions, otherwise the assumption of any such motion would be gratuitous. In regard to the radiation of hydrogenous and mixed atoms having the fixation of oxygen in combustion, Sir Richard Phillips conceives, that their minuteness and great velocity is the cause of their extensive radiation, though many of them are doubtless impeded, and hence their proportionate progress through bodies of various structures; but that light consists of atoms in motion, is evident from the heat which these create when falling on surfaces that arrest and fix them, a result in accordance with the entire theory.

ELATINE. A vegetable principle lately discovered in the juice of the seeds of the momordica elaterium, or cucumber. It is most violently purgative. It is found in exceedingly minute quantities. The following, according to Dr. Paris, is the composition of elaterium:—

Water	4
Extractive	26
Fecula	28
Gluten	5
Woody matter	25
Elatine, bitter principle	12
	100

The bitter principle is very different from the extractive. The solution of the bitter principle and elatine produced increase of appetite; whilst the solution of the extractive matter produced no effect at all.

ELAOLITE. A sub-species of pyramidal felspar.

ELECTIVE ATTRACTION. There are various kinds of attraction; as attraction of cohesion or adhesion; for which see the article ADHESION. Attraction of gravitation, by which the planetary bodies are drawn towards the sun; attraction of magnetism manifested between the magnet and the iron; attraction of electricity, by which two bodies differently electrified approach each other; which three last kinds of attraction are more properly noticed in a work on natural philosophy. There is another kind of attraction, which is strictly chemical, and is also called affinity, by which the particles of bodies unite together, and by their union produce a uniform whole of such a nature that the parts cannot be separated by any mechanical efforts; and the characteristic properties of which, are often very different from those of the original component parts. Thus, if sulphur be melted, and combined with soda, there will be formed a substance, which from its colour, has been called liver of sulphur. Let this mass be divided and sub-divided ever so much, there will still be in the smallest part a particle both of the sulphur and the soda. This union differs from mere mixture, which may again be separated.

Sand and salt exposed to a strong heat combine and form glass. No mechanical efforts can separate the glass into particles of sand and salt. By such union in chemical bodies, the properties are frequently changed, and thus the properties of glass are quite different from those either of the sand or of the salt. This however, is not universally the case, and it may happen, that after the union, the distinctive properties of each of the component parts will still be perceptible. This is more particularly the case when two gases are united together; and therefore, it is by experiment alone, that we can with certainty learn what powers bodies will acquire by com-

bination. As a general rule, however, we may expect that there will be a considerable change. If mercury and sulphur be put into the same crucible, and put in the fire, melted, and stirred together, and then poured out, a substance will be found to have been formed, which is called sulphuret of mercury, which has neither the colour nor the brilliancy of the mercury, nor the inflammability of the sulphur. To the same law of chemical affinity, we refer the union of salt and water; of alcohol and camphor; of sulphuric acid and alumina, of nitric acid and potass; of silver and gold; or in general, the alloys of all the metals.

A few instances are here given:

Put some sugar, muriate of soda, (common salt,) or any other salt, into an ounce of water, until no more will be dissolved. The solution will measure just an ounce, as the water did before the addition of the salt: but although there is no increase of *bulk*, there is a considerable increase of *density* and *specific gravity*.

Pour into a phial half an ounce of any animal or vegetable oil, (as olive oil,) add to it the same quantity of water, and shake the phial violently. No appearance of combination will take place, for whenever the agitation ceases, the oil will be seen to rise to the surface of the water. Now throw in two drams of soda, potass, or ammonia, and shake again. The case will now be different, for the alkali combining with the oil, forms a soap, which is readily miscible with water, and the whole will have the appearance of thick cream.

If mercury be poured into a wine glass, its upper surface will be convex; that is, a kind of foss or trench will be formed all round the mercury, between it and the edges of the glass. Here no affinity exists between mercury and glass; but if the mercury be poured from the glass, into a tin, brass, or other metallic cup, the upper surface will be *concave*, from the affinity which it has for these metals; and of course from its consequent adhesion to them.

Over iron-filings, in a wine glass, pour a small quantity of any of the following acids, in a diluted state, viz. the sulphuric, nitric, muriatic, or acetic, each of which has the power of attacking the iron. During all these combinations, violent effervescence will take place, occasioned by a rapid disengagement of hydrogen gas from the water, which is decomposed by the mutual action of the metal and the acid. But when the nitric acid is used, a great deal of nitrous gas will be evolved. The ultimate products of these combinations will be either sulphate, nitrate, muriate, or acetate, of iron, according to the acid employed. The solutions should be evaporated and crystallized; or put into phials for future use.

The presence of water promotes chemical union.—If the strongest nitric acid be poured on mercury in a wine glass, very little or no action will take place between these substances; but, if water be added, an immediate solution, attended by a most active effervescence, or salient motion of the mercury in the fluid, will take place. During this eagerness of the two bodies to unite, a variety of colours, but chiefly green, will be presented to the eye; and nitrous fumes will be disengaged in abundance. When the effervescence ceases, the metal will be dissolved, and the whole converted into a transparent liquid, like water. If a small quantity of the metal should remain undissolved, after the action ceases, a slight addition of the acid will cause the effervescence and solution to recommence. Evaporation, in a warm place will convert this solution into crystals, known by the name of nitrate of mercury.

Change of colour is very frequently produced. Thus, a few drops of acid let fall into a glass of the tincture of red cabbage will immediately turn it to a red colour; but if an alkali had been put into it, the colour would have become green.

In chemical combinations there is usually great heat produced.

It is between the minutest particles of bodies that chemical affinity

takes place. Several bodies are sometimes chemically united together. Thus, lead, bismuth, and tin, in various proportions; or lead, bismuth, and zinc; or lead, bismuth, tin, and mercury.

But there is not merely a chemical attraction by which two bodies unite together, but there is also an *elective* attraction, by which one body will unite with another, rejecting a third body, with which, but for the presence of the second body, it would have united. Therefore, we may describe elective attraction, as that which is exerted between two substances to the exclusion of a third. It is often the case, that when two substances are united, communication with a third will destroy the connection or affinity which existed between them: and instead of this alliance, another will be formed, between the new agent, and that part of the former compound, for which it had the greatest affinity. The meaning of elective attraction, then, is, that the third body, has the power of making an election, according to its nature, of whatever body it shall unite itself with from the first and second. If the second be chosen, the first shall be excluded; or if the first be chosen, the second shall be excluded.

One of the simplest and most usual instances of this elective attraction, is that of potass or soda with acids, in preference to tallow or oils.

Dissolve half an ounce of common soap in a tea-cup with a little warm water; when it is quite clear decant it into a wine glass, and pour into it 10 drops of sulphuric or muriatic acid. The tallow of the soap will be precipitated, and being lighter than the water will swim on its surface. This precipitation is owing to the greater affinity which the alkali has for any acid than for fat or resin.

In this way, tallow is precipitated on the surface of water in a wash-hand basin, from the quantity of acid held in solution, in combination with earths, &c. Hence it is that water containing acids, is unfit for washing, the soap being decomposed by the alkali in it, uniting with the acid.

Metals have an elective attraction for each other. Thus, if an alloy of gold and silver be melted together in a crucible, the gold may be separated from the silver by stirring the melted metal with a piece of copper. The gold will adhere to the copper, abandoning the silver, and from the surface of the copper it may without difficulty be got off.

It is this principle of elective attraction, which affords the means of decomposing different bodies. If a substance be compounded of two substances, in order to separate them, it is only required to bring in contact a third substance, for which one of them has a superior attraction, and the decomposition takes place. Thus, into a solution of a metal in an acid pour a solution of potass, and the acid and the potash uniting together, the metal is separated from the acid, and thrown to the bottom.

The following experiments will shew the order of affinity of some of the acids for potass:—

That of the acetic is greater than carbonic.—Put some carbonate of potass into a tumbler, and pour over it diluted acetic acid; (common distilled vinegar; which must previously be proved, by barytes, to contain no sulphuric acid,) this acid will dissolve the potass and expel the carbonic acid with effervescence. The newly formed compound will be acetate of potass.

The attraction of the muriatic is greater than acetic.—Into the newly formed solution of acetate of potass, pour some muriatic acid as long as an acetic smell arises from the tumbler: this smell will be occasioned by the expulsion and evolution of the acetic acid. The new compound will be muriate of potass. This salt will crystallize in cubes, and is slightly deliquescent.

The attraction of the nitric is greater than muriatic.—Into the solution of muriate of potass, obtained in the last experiment, pour some nitric acid, this will expel the muriatic acid; and a quantity of nitrate of potass will be held in solution. This salt may be crystallized; but the crystals

are rather irregular, presenting a variety of forms.

The attraction of the sulphuric is greater than nitric.—Into the solution of nitrate of potass obtained in the last experiment, pour some sulphuric acid; a solution of sulphate of potass will now be formed. This salt may be crystallized in six-sided prisms having pyramidal tops.

The order of affinity of potass for the different acids, is proved by the foregoing experiments to be as follows: carbonic acid; acetic acid; muriatic acid; nitric acid; and sulphuric acid. For the last of these it has greater affinity than for any of the others; and for the first less than for any that follow. If these experiments are assisted by heat the result will be more satisfactory, as the different acids discharged may be received from a tubulated retort into a receiver, and then proved by tests.

By the following experiments, we may see the order of the attraction of sulphuric, muriatic, and carbonic acids for lime.

Order of affinity of sulphuric, muriatic, and carbonic acids, for lime.—Put some powdered carbonate of lime (chalk) into a tubulated retort with water, and pour some muriatic acid over it. After the expulsion of common air, immerse the beak of the retort under a glass, containing ammoniacal gas placed over mercury: a gas will ascend, which may be proved to be carbonic acid gas by its union with the ammoniacal gas; both forming a solid salt, the carbonate of ammonia. The compound in the retort will be muriate of lime. If when all the carbonic acid gas is driven off, sulphuric acid be poured into the retort, and its beak be immersed under another jar, containing ammoniacal gas, muriatic acid gas will ascend in the jar, and combine with the ammonia, forming also a solid salt, called muriate of ammonia, a substance destitute of smell, although both the articles used in its formation possess separately a most pungent odour. The salt now left in the retort will be an insoluble one, namely, the sulphate of lime: whereas, the former one, the muriate of lime, is one of the most soluble salts; and the one before that, the carbonate of lime, is only partly soluble.

It is by means of a series of well conducted experiments of this sort, that chemists have been able to form tables, shewing, at one view, the elective attraction of any body for all other bodies.

The chemical affinities of bodies are modified by temperature, and other adventitious circumstances.

When a body made up of two bodies combined together, is united with another body, also made up of two bodies, there may be a double decomposition. Thus if the sulphate of ammonia be added to the nitrate of potass, there will be a double decomposition, and the sulphuric acid will leave the ammonia, and will unite with the potass; and the nitric acid will unite with the ammonia; and the result will be sulphate of potass and nitrate of ammonia.

There are many substances which cannot be decomposed by any other way.

There are, also, substances formed, of the highest utility in the arts, by this principle, which can be formed in no other manner. Thus, acetate of alumina, which is much used in calico printing, cannot be made by mixing acetic acid with alumina; but only by mixing sulphate of alumina with acetate of lead, when a double decomposition takes place, and acetate of alumina is formed.

Mix together a solution of nitrate of silver and a solution of muriate of lime; and a double decomposition will take place, and two new substances will be formed; nitrate of lime, and muriate of silver; the latter of which, being insoluble in water, will fall to the bottom in a solid state: and by evaporation of the liquid, the nitrate of lime will be made to appear.

In giving this account of the phenomena of chemical attraction, our object has been to state the facts, and we have not attempted, as many chemists have done, often with little success, to explain the causes of these phenomena; and we have made use of the usual popular terms. Some chemists,

not content with laying down a theory, have even attempted a mathematical investigation of the laws of the forces of chemical attraction, and have brought into discussion the ratios of squares, cubes, &c. The chemical student ought always to make a careful distinction between the universally acknowledged facts and the disputed theories, by which they are explained; the one being certain and unchanging truth, and the latter often of a very transitory reception in the estimation of the scientific. The usual theories of the day, are most ably attacked by Sir Richard Phillips, in his Twelve Essays on the Proximate Causes of the Material Phenomena of the Universe. "The doctrine of affinity," observes Sir Richard, "is liable to the same objection as that of gravitation. Atoms cannot impel each other on their *contrary* or *opposite* sides; and it will not be pretended that they *draw* one another by any *mechanism* on their *inner* sides! The chemists talk, however, with imposing solemnity, of attractive forces greater than that of the squares, as the cubes, &c. &c.; but, as distant force is merely in all cases the effect of the divergence of a central force, any other law than that of the squares, as far as could depend on the centre, is a mathematical absurdity. But, in truth, even the law of the squares is inapplicable, for atoms do not approach each other in consequence of any power of drawing in their emanations or attractive particles; and the notion is ridiculous in terms, when it is pretended that a *primary* atom, or even a compounded atom of chemical bulk, has *spare* atoms to send forth, for the purpose of *bringing* other atoms towards it.

"Let us look, however, to first principles, and chemical affinity will cease to be a difficulty. Space is *full* of primary and compounded atoms of various kinds. These atoms are of various forms. If, then, by local excitements of atomic motion,—either by aggregate motion transferred to atoms, called heat, or by any other action, —the atoms of any form are displaced in regard to one another, a vacuity is created, or tended to be created, between the sides of the atoms, which vacuity the atoms of space endeavour to fill; and hence a pressure of the adjoining atoms, with a *force*, governed by the circumstances of the vacuity, or vacuities, created or tended to be created, and the relative forms of the bodies, added to their capability of moving and filling the vacuity.

"The force in every case depending, therefore, on the disturbance and vacuity created, and on the appropriateness of the adjoining atoms to maintain the fulness of space, may be an approximation to any law as the square, the cube, the fourth, fifth, or tenth power. It is a law which may be determined in regard to the commixture of particular bodies, *cæteris paribus*, but is not necessarily any multiple of the distance; for the notion of the multiple of the distance springs from a false analogy in this case, prevailing only in the square, because the surfaces of spheres (over which central forces diffuse themselves) are as the squares of their radii.

"The force of chemical affinity must be evident to any one who views a body composed of cubic atoms without having recourse to any legerdemain principle. They are like a solid battalion of infantry, which, to other soldiery, is impenetrable; and they present, to other atoms, the same impenetrable sides. Like them, they may be assailed with aggregate motion, which, like cannon-balls, will shatter them in mass; or they may be killed man by man, or moved atom by atom, by small shot, or attacks of successive atoms. But in this case the force of affinity is a simple result of form, and not an effect of any attraction, or any *hocus pocus* quality in the soldiers, or the atoms.

"It should be remembered that, in all cases of simple chemical action, *we do but oppose atoms to atoms*; and, if we desire to combine atoms, we must assail them by the transfer of aggregate motion, called heat; and we must present those of similar forms, or of such combinations of dissimilar forms, as produce forms similar, or nearly similar.

"Without these conditions we can never, by means of atoms themselves, penetrate a congeries or solid formation in which their sides fit; but, having disturbed the mass by heat, or the atomic affection of aggregate motion, called heat, if atoms of dissimiliar forms are then presented they will combine. But they will be expelled when the motion ceases, and the dissimilar atoms will then separate again, or, in the superstitious jargon, will be *repelled*, each returning to its original state.

"Such is chemical affinity or attraction, disturbance, and repulsion. The theory results from our knowledge of atomic forms in the varied construction of solids; from the necessary fulness of space; and from the power which we possess of bringing aggregate motion, or the motion of millions of atoms, to bear under the name of heat, on masses, which, otherwise, no mere atomic force would ever disturb. The first condition has been proved by Haüy, Daniel, and others: the subsequent ones have been discussed in former Essays, and are assumed as truths proved, as well by these as by other phenomena.

"Air becomes a *solvent*, or agent of decomposition, owing to the atomic motion by which its rare atoms in motion agitate and abrade the atoms excited or dovetailed on the one degree of force; while the general oxydation, in this case, proves that the oxygenous atoms are the operating ones · water, in like manner, and in a higher degree, because more dense; and, having more atoms in the same space, it is still higher when the atoms are agitated by more motion or heat, and is more and more potent as the heat, or motion of the water, is increased. So, with other solvents, which act with a degree proportioned to the degree in which their atoms, or parts of their atoms, are susceptible of receiving and imparting any motion.

"Chemical polarity, as it may be called, is a necessary consequence, *caeteris paribus*, of the union of atomic forms, whose angles oppose their union or movement in one direction of motion, but permit it in another."

ELECTRICITY. This subject belongs more properly to natural philosophy, and we merely notice it to remark, that it has been applied with advantage in chemical research, in fusing and decomposing various bodies; and that branch of electricity, or kindred science, called galvanism or voltaism, in the hands of Sir Humphrey Davy, has been the chief source of grand and luminous discoveries, which have immortalized his name.

ELECTRUM. An ore of gold containing 64 parts of gold, and 36 of silver.

ELEMENTS. A term used by the earlier chemists, nearly in the same sense as the moderns use the term *first principle*. The chief, and indeed very essential difference between them is, that the ancients considered their elements as bodies possessing absolute simplicity, and capable of forming all other bodies by their mutual combination; whereas the first principles of the moderns are considered as simple, merely in respect to the present state of the art of analyzing bodies.

ELEMI. A resin, which exudes from incisions made, in dry weather, through the bark of the amyris elemifera, a tree which grows in America.

ELIQUATION. An operation, by means of which a more fusible substance is separated from another which is less fusible. It consists in the application of a degree of heat sufficient to fuse the former, but not the latter.

ELUTRIATION. This word is used by chemists to denote the process of washing, which carries off the lighter earthy parts, while the heavier metallic parts subside to the bottom.

EMERALD. The precious stones of a beautiful green colour, are divided into two species, the prismatic and rhomboidal.

The prismatic is of specific gravity for 2.9 to 3.3. It is harder than quartz, but less so than topaz. Its constituents are 35 to 36 silica, 18 to 19 alumina, 14 to 15 glucina, 2 to 3 iron, and 27 to 31 loss; the latter consists chiefly of water and

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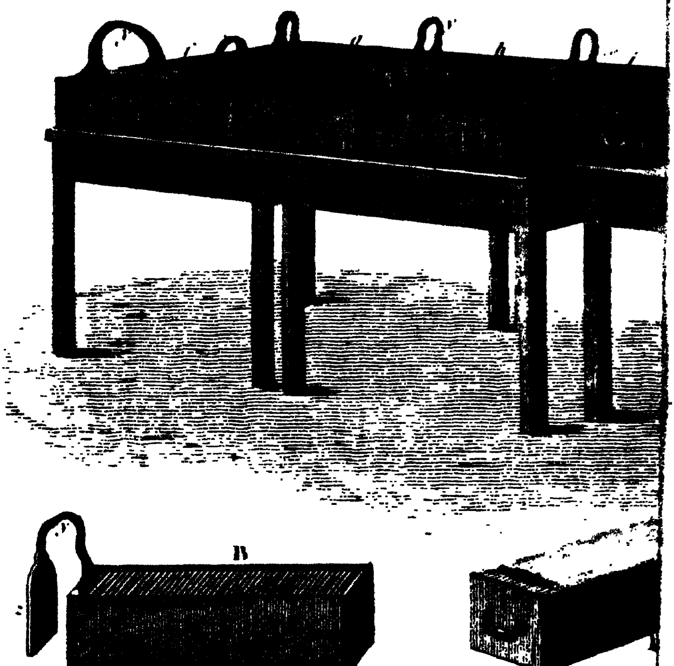


alkali. It is found in Peru and Brazil; but though very beautiful, it is too brittle for jewellers.

The rhomboidal emerald is in value next to the ruby. The most beautiful come from Peru. It is known by its fine green colour. It is nearly as hard as the topaz. It consists of silica 64.5, alumina 16, glucina 13, oxide 1, chromium 3.25, lime 1.6, and water 2. The beryl is a sub-species of emerald.

EMERY. The powder of emery, which is obtained by reducing to powder the mineral which yields it, and washing it so as to carry off the lighter earthy particles, is very well known for its use in polishing hard minerals and metals. It is used in giving an edge to tools. It consists of 86 alumina, 3 silica, 4 iron, and 7 loss. This mineral is very hard so as to scratch topaz. Specific gravity 4.0.

EMETIN is a substance obtained from the root ipecacuan. Half a grain is a powerful emetic, and six grains vomit violently, and produce death.

EMPYREUMA. This term is applied to denote the peculiar smell produced by a considerable heat upon vegetable or animal substances in closed vessels, or when burned under circumstances which prevent the access of air to a considerable part of the mass, and consequently occasion an imperfect combustion, or destructive distillation of the parts so covered up by the rest of the mass.

EMULSION. An imperfect combination of oil and water, by the intervention of some other substance capable of combining with both these substances. The substances are either saccharine or mucilaginous.

ENAMEL. There are two kinds of enamel, the opaque and the transparent. Transparent enamels are usually rendered opaque by adding putty, or the white oxide of tin, to them. The bases of all enamels is therefore a perfectly transparent and fusible glass. The oxide of tin renders this of a beautiful white, the perfection of which is greater when a small quantity of manganese is likewise added. If the oxide of tin be not sufficient to destroy the transparency of the mixture, it produces a semi-opaque glass, resembling the opal.

Yellow enamel is formed by the addition of oxide of lead, or antimony. Kunckel likewise affirms, that a beautiful yellow may be obtained from silver.

Red enamel is afforded by the oxide of gold, and also by that of iron. The former is the most beautiful, and stands the fire very well, which the latter does not.

Oxide of copper affords a green; manganese, a violet; cobalt, a blue; and iron, a very fine black. A mixture of these different enamels produces a great variety of intermediate colours, according to their nature and proportion. In this branch of the art, the coloured enamels are sometimes mixed with each other, and sometimes the oxides are mixed before they are added to the vitreous bases.

The following are Mr. Wynn's fluxes for enamels in a paper presented to the Society of Arts in 1817:—

No. 1.	Red lead,	8 parts.
	Calcined borax,	1½
	Flint powder,	2
	Flint glass,	6
No. 2.	Flint glass,	10
	White arsenic,	1
	Nitre,	1
No. 3.	Red lead,	1
	Flint glass,	3
No. 4.	Red lead,	9¼
	Borax not calcined,	5¼
	Flint glass,	8
No. 5.	Flint glass,	6
	Flux, No. 2.	4
	Red lead,	8

After the fluxes have been melted, they should be poured on a flag stone, wet with a sponge; or into a large pan of clean water, then dried, and finely pounded in a biscuit-ware mortar for use.

Yellow enamel.

Red lead,	8
Oxide of antimony,	1
White oxide of tin,	1

Mix the ingredients well in a biscuit-ware mortar, and having put them on a piece of Dutch tile in the muffle, make it gradually red-hot, and suffer it to cool. Take

of this mixture 1, of flux No. 4. 1½; grind them in water for use. By varying the proportions of red lead and antimony, different shades of colour may be obtained.

Orange.

Red lead,	12
Red sulphate of iron,	1
Oxide of antimony,	4
Flint powder,	3

After calcining these without melting, fuse 1 part of the compound with 2½ of flux.

Dark red.

Sulphate of iron calcined dark, } 1
Flux, No. 4. 6 parts } of this 3
Colcothar, 1 }

Light red.

Red sulphate of iron,	1
Flux, No. 1.	3
White lead,	1½

Brown.

Manganese,	2½
Red lead,	8½
Flint powder,	4

ENTROCHI. A genus of extraneous fossils, usually of about an inch in length, and made up of a number of round joints, which, when separate and loose, are called trochitæ: they are composed of the same kind of plated spar with the fossil shells of the echini, which is usually of a bluish-grey colour, and are very bright where fresh broken: they are all striated from the centre to the circumference, and have a cavity in the middle. They seem to be the petrified arms of that singular species of the sea star-fish, called stella arborescens.

EPIDOTE. Pistacite of Werner. A species of prismatoidal augite. It consists of silica 37, alumina 21, lime 15, oxide of iron 24, oxide of manganese 1.5, water 1.5.

EPIDERMIS. If the human skin be macerated in hot water, it separates into two parts, the *cutis*, or true skin, and the *epidermis*, or scarf skin. The continued action of warm water at length dissolves the cutis, but does not affect the epidermis, neither does alcohol. Caustic alkali, however, dissolves it. It resembles coagulated albumen.

EPSOM SALT. The sulphate of magnesia. They are called Epsom salts because they have been obtained from a salt spring at Epsom; but they are usually procured from the mother waters, which are the sea water, which is left after it has been so far boiled down, that the common salt, the muriate of soda, has precipitated to the bottom. If this liquor be farther evaporated, in another vessel, sulphate of magnesia is obtained.

EQUIVALENTS (CHEMICAL). ATOMIC THEORY.—If certain quantities of two different bodies be each of them sufficient to neutralize a third body, these two quantities are said to be equivalent to each other. Thus 100 parts of sulphuric acid, and the 68 of muriatic acid will each of them saturate 118 parts of potash: in this case we say, that the 100 and the 68 are equivalent to each other. We shall accordingly find, that if 100 parts of sulphuric acid neutralize 71 parts of lime, that 68 of muriatic acid will also do the same thing; and so on in any other case in that proportion. If therefore we know, that any number of parts of sulphuric acid will saturate any substance; in order to find how many parts of muriatic acid will be necessary, we have only to state 100 : 68 : : the parts of sulphuric : parts of muriatic acid required.

If in this way the quantity of sulphuric acid necessary to saturate any quantity of soda, magnesia, strontian, iron, and all other substances, be ascertained, we shall be able to know what quantity of muriatic will be required. And if we ascertain by experiment, how much acetic acid will be required to saturate any one of these substances, we may by calculation tell what quantity will be necessary for any one of the rest, as we know its saturating power compared with two acids, the powers of which are already known.

When two bodies unite to form one compound, it is remarkable, that at all times whenever that compound is produced, under whatsoever circumstances, whether by nature or art, it always contains the same relative proportions of its component parts. Thus, one volume of hydrogen unites with half that volume of oxygen in the

formation of water. Two cubic inches of hydrogen unite by combustion with one of oxygen, and water is the result. If there should be three cubic inches of hydrogen, and one oxygen, in that case water would be produced as before, and of the same component parts; but there would be one cubic inch of hydrogen remaining as before. In like manner, if there be two cubic inches of hydrogen, and two of oxygen and water be produced by their union, there would remain one cubic inch of oxygen as before. In either case, the surplus is left unchanged.

Gases in their mutual action uniformly combine in the most simple proportions, such as 1 to 1, 1 to 2, or 1 to 3 by volume.

The same simplicity of ratio will not hold in their combination by weight.

Sometimes two bodies combine together, in different proportions; but then it is not like water and spirits, in any proportions whatever with which which they may be mixed; but only in certain definite proportions. Thus, potash and carbonic acid unite together in the proportion of 70 potash, and 30 carbonic acid, forming sub-carbonate of potash; and 70 potash and 60 carbonic acid, forming crystallized carbonate of potash, but without any intermediate combinations. Lead combines with oxygen in three proportions:—

100 lead and 8 oxygen.
100 lead and 12 oxygen.
100 lead and 16 oxygen.

Potash and oxalic acid unite together to form oxalate of potash, in the proportions of 2 potash and 1 acid; they also unite to form benoxlate of potash, in the proportion of 2 potash, and 2 acid; and to form quadroxalate, they unite in the proportion of 2 potash, and 4 acid.

Upon these principles is founded what is called the Atomic Theory. It is assumed that, two different bodies, chemically combine together only in the atoms, or infinitely minute parts.

This is, however, merely an assumption, and incapable of proof; for we can never be certain that we have arrived at the ultimate atoms of bodies; and if matter be infinitely divisible, there are no ultimate atoms.

Although, however this be merely an assumption, it is rendered highly probable, and will correspond with the facts deduced from the analysis of gaseous, liquid, and solid bodies.

There is reason to fear, however, in a great variety of instances, that the prejudice in favour of the atomic theory has had too great weight in deciding the judgment of the chemist in his analysis; and that results in favour of this theory have been obtained, where, without such a bias, there would not have been such coincidence. This is one of the numerous cases in chemistry, where implicit faith is to be withheld, and where much remains to be explored by farther investigation.

In forming a table of equivalent numbers, corresponding with what is supposed to be the proportionate bulk of the ultimate atoms of bodies, hydrogen is, by Sir H. Davy, assumed as the basis, and is called 1; oxygen will then be 8, and chlorine 36.

Hydrogen is the fittest to form the basis, as it is the substance which approaches the nearest to what the elements, or ultimate atoms may be supposed to be. It has energetic powers of combination, its parts are repulsive of each other, and attractive of the particles of other matter; and it enters into combination in a quantity much smaller than any other substance.

Some have assumed oxygen as the basis of their table of equivalents. But the numbers in the one table are reducible to those of the other.

When the improvements, which may be expected, are hereafter made on this subject, such tables will be of much use in ascertaining the component parts of compound chemical substances.

ESSENCES. The volatile or essential oils are called essences by the perfumers.

ESSENTIAL OIL, or VOLA-

TILE OIL, differs from fixed oil in being capable of evaporation at a much lower heat; in being soluble in alcohol; and in possessing a very slight degree of solubility in water.

There is a great number of volatile oils, distinguished by their smell, their taste, their specific gravity, and other sensible qualities. A strong and peculiar odour may, however, be considered as the great characteristic of each species, the volatile oils inflame with more facility than the fixed oils, and afford, by their combustion, different proportions of the same substances, water, carbonic acid, and carbon.

The following specific gravities of different volatile oils, were ascertained by Dr. Lewis :—

Oil of Sassafras	1094
Cinnamon	1035
Cloves	1034
Fennel	997
Dill	994
Penny-royal	978
Cummin	975
Mint	975
Nutmegs	948
Tansy	946
Carroway	940
Rosemary	934
Juniper	911
Oranges	888
Turpentine	792

The peculiar odours of plants, seem in almost all cases, to depend upon the peculiar volatile oils they contain. All the perfumed distilled waters owe their peculiar properties to the volatile oils they hold in solution. By collecting the aromatic oils, the fragrance of flowers, so fugitive in the common course of nature, is as it were embodied, and made permanent.

It cannot be doubted that the volatile oils consist of carbon, hydrogen, and oxygen; but no accurate experiments have as yet been made on the proportion in which these elements are combined.

The volatile oils have never been used as articles of food, many of them are employed in the arts in the manufacture of pigments and varnishes, but their most extensive application is as perfumes.

ETHER. A very volatile fluid, produced by the distillation of alcohol with an acid.

When strong sulphuric acid is poured upon an equal weight of alcohol, the fluids unite with a hissing noise and the production of heat, at the same time that a fragrant vegetable smell is perceived, resembling that of apples. It is much better and safer, however, to add the acid by small portions at a time, at such intervals as that no perceptible heat may be produced. The mixture may be made in a glass retort, and the distillation performed by regulated heat on a sand-bath, a large tubulated receiver being previously well adapted, and kept cool by immersion in water, or the frequent application of wet cloths. A bent glass tube luted to the tubular of the receiver, and having its extremity immersed in a little water or mercury, will allow the gases to escape, and confine the condensible vapour. The first product is a fragrant spirit of wine, which is followed by the ether, as soon as the fluid in the retort begins to boil. At this period, the upper part of the receiver is covered with large distinct streams of the fluid which run down its sides. After the ether has passed over, sulphurous acid arises, which is known by its white fume and peculiar smell. At this period the receiver must be unluted and removed, care being taken to avoid breathing the penetrating fumes of the acid; and the fire must at the same time be moderated, because the residue in the retort is disposed to swell. A light yellow oil, called sweet oil of wine, comes over after the ether, and is succeeded by black and foul sulphuric acid. The residue varies in its properties according to the management of the heat. If the fire be much increased toward the end of the process, the sulphurous acid that comes over, will be mixed with vinegar.

The ether comes over mixed with alcohol and some sulphurous acid. It was usual to add some distilled water to this product, which occasioned the ether to rise to the top. Rectification is absolutely necessary, if the ether have a sulphurous smell;

and this is indeed the better method in all cases, because the water added in the old method always absorbs about one-tenth part of its weight of ether, which cannot be recovered without having recourse to distillation; and also because the ether is found to absorb a quantity of the water. Previous to the rectification, a small quantity of black oxide of manganese should be added, shaking the mixture occasionally during 24 hours. Proust prefers clean slaked lime, as recommended by Woolfe; observing that the bottle must not be above three parts filled, and that it must be moved about in cold water for some minutes before the cork is taken out.

The inexperienced chemist must be reminded, that of the extreme inflammability of alcohol, and still more of ether; the danger of explosion which attends the sudden mixture and agitation of concentrated acids and alcohol; and the suffocating effect of the elastic fluids, which might fill the apartment if inadvertently disengaged; are all circumstances which require cautious management.

Sulphuric ether is a very fragrant, light, and volatile fluid. Its evaporation produces extreme cold. It is highly inflammable, burns with a more luminous flame than alcohol, which is of a deep blue, and emits more smoke. At 46° below 0 of Fahrenheit it becomes solid. It dissolves essential oils and resins, and camphor very plentifully. By long digestion it dissolves 1-13th of sulphur in the light, and 1-17th in the dark. This preparation Mr. Favre recommends as an excellent test of lead in wine, which it throws down in a black precipitate. Mixed with the muriatic solution of gold it retains a portion of the metal in solution for some time.

To render ether still more pure, it may be mixed with subcarbonate of potass, and again distilled. Ether boils at 98° Fahrenheit. Ether, according to Saussure, consists of

Hydrogen . .	14.40
Oxygen . . .	67.98
Carbon . . .	17.62
	100.0

The muriatic, nitric, the hydriodic, the acetic, the benzoic, oxalic, citric, and tartaric acids, may be united with alcohol, and a peculiar species of ether in each case obtained.

ETHIOPS (MARTIAL). Black oxide of iron.

ETHIOPS (MINERAL). The black sulphuret of mercury.

EVAPORATION. A chemical operation usually performed by applying heat to any compound substance, in order to dispel the volatile parts. It differs from distillation in its object, which chiefly consists in preserving the more fixed matters, while the volatile substances are dissipated and lost. And the vessels are accordingly different, evaporation being commonly made in open shallow vessels, and distillation in an apparatus nearly closed from the external air.

The degree of heat must be duly regulated in evaporation. When the fixed and more volatile matters do not greatly differ in their tendency to fly off, the heat must be very carefully adjusted; but in other cases this is less necessary.

As evaporation consists in the assumption of the elastic form, its rapidity will be in proportion to the degree of heat and the diminution of the pressure of the atmosphere. A current of air is likewise of service in this process.

There is a very effectual, and economical mode in which liquors are evaporated in some manufactories. A very large water-tight stone trough, or cistern, 4 feet broad, 2 deep, and 20, 30, or 40 long, is covered above by a low brick arch. At one extremity of this arch a grate is built, and at the other a chimney. A fire being lighted in this grate, the warm air is carried along the surface of the liquor to the other end, and rises up the chimney. The heated air promotes evaporation, and as it is quickly carried off, bearing with it all the vapour which had risen up, and new air comes in contact, the process goes on with great rapidity. It is supposed that evaporation will go on more quickly from a covered vessel, from the top of

which a pipe issues, than when the liquor is freely exposed to the air.

Evaporation depends much upon the surface of land or water exposed to the atmosphere:—from seas and rivers it is very great. They send up as much vapour as is equal to their supply of water from streams and rain; and the balance is kept up by future condensation. Dr. Halley found, that the quantity of water evaporated from the Mediterranean sea, in a summer day, amounts to 5,280 millions of tons! Mr. Dalton found, that the evaporation from water in a flat vessel, exposed to the sun, was about 0.2 of an inch, in an intensely hot summer day. By the following table, it will be seen, that the *mean* evaporation from the surface of water throughout the year, is 36.78 inches. The proportions for each month are as follows:—

	Inches.
January . .	1.50
February . .	1.77
March . . .	2.64
April . . .	3.30
May . . .	4.34
June . . .	4.41
July . . .	5.11
August . .	5.01
September .	3.18
October . .	2.51
November .	1.51
December .	1.49

Bishop Watson asserted, that even in the heat of summer, when there is no rain, and the ground is dried up, no less than 1,600 gallons of water are evaporated from a single acre in one day. What must be the quantity of water evaporated from the surface of the whole earth and seas in this time! And what must the bulk of that vapour be, when each gallon of water is expanded to 1,400 times its original bulk! It may be asked, what is the use of this immense evaporation? Where does the vapour go to? And does not the earth feel the loss of so great a quantity of that moisture, which renders it fertile? To this it is answered, that, for a short time, the vapour is sustained in the form of clouds; that these clouds are condensed in due time by electricity; that this condensation is in the shape of mist, dew, rain, snow, and hail, which falling on the earth, fertilize all parts of it; and that, were it not for this mode of condensation, the inlands of all countries would be deprived of moisture, and rendered complete deserts, unfit for the nourishment of animals or vegetables.

Evaporation is much increased when the temperature of fluids i raised by natural or artificial means.—Liquids will sooner be converted into vapour in the heat of summer, or in warm climates, than in winter, or in cold ones. When heat is applied to liquids, a very quick evaporation takes place. This cannot be better exemplified, than when water in a saucepan or tea-kettle emits vapour from combination with the heat of a fire.

All salts are separated from their solutions by evaporation; for the water rises in vapour, and leaves the solid particles to crystallize. This may be proved by dissolving any salt in water, and then placing the vessel containing it close by the fire;—when the water disappears crystals will be formed. In the large way, saline solutions are first *boiled*, to rid them of the main body of water, (which being formed into vapour, speedily flies off;) and having thus attained a certain consistency, or having become *thicker*, they are poured into shallow vats; a more moderate heat is now applied, by which a slow evaporation is kept up, so as to prevent disturbance of the crystallization; and in due time the desired effect is produced. In this way, muriate of soda, (sea salt,) carbonates of soda, and potass, sulphate of magnesia, sugar, &c. &c. are obtained. The late Mr. Thompson has applied steam to the evaporation of solutions of sulphate of potass, &c. found at Cheltenham. A chamber, containing a dozen of vats, is heated by pipes proceeding from a steam-boiler; thus the evaporation is performed with little trouble or expense.

In warm countries, large pools are filled with sea and other saline waters, from which the solar heat causes quick evaporation, leaving the salt behind. This art is known to the South Sea Islanders. In the Bay of Biscay, bay-salt is made in the same way. The Egyptian lakes, where soda is obtained, are filled by the overflowing of the Nile, and afterwards dried up by the heat of the sun, the salt is accordingly left behind. Borate of soda is obtained from the waters of a lake in Thibet, by the same process. The solution is poured into shallow cavities made in the earth, and evaporated by the heat of the sun. In this country too, sea-water is first evaporated in pits, before it is submitted to ebullition. All saline solutions are thus *concentrated*, and, of course, do not require so much expense of fuel.

In lowering the temperature of bodies, evaporation is of extensive use.

Wines may be cooled, by wrapping the bottles round with wet cloths. Wine-coolers act upon the same principle; for the vessels into which the bottles are put, are made of a spungy or porous ware, through which the water exudes. This water evaporates, and in doing so, robs the wine of its heat.

Wet cloths are used in Asiatic countries, to cover the windows; by which means the apartments in the houses are kept cool. A similar precaution is taken in Sicily and Malta, during the period of the *sirocco*, or hot wind. Evaporation, by sprinkling the floors with perfumed waters, is a luxury much used by Eastern monarchs. After rain, the weather is cold, in consequence of an immediate and extensive evaporation.

A most cruel kind of punishment is practised in one of the Asiatic countries. The head of the criminal is shaved, and he is placed in such a situation that drops of water continue descending upon one part of his head, by capillary attraction, from a vessel above. The drops evaporate, and consequently carry away as much heat as gives to them the elastic form; and as one does not descend until the other is dried up, the continual abstraction of heat is the cause of extreme agony. The unfortunate victim dies raving mad.

EUCHLORINE. Protoxide of chlorine.

EUCLASE. Prismatic emerald.

EUDIOMETER. An instrument for ascertaining the purity of air, or rather the quantity of oxygen contained in any given bulk of elastic fluid. Dr. Priestley's discovery of the great readiness with which nitrous gas combines with oxygen, and is precipitated in the form of nitric acid, was the basis upon which he constructed the first instrument of this kind.

His method was very simple: a glass vessel, containing an ounce by measure, was filled with the air to be examined, which was transferred from it to a jar of an inch and half diameter, inverted in water; an equal measure of fresh nitrous gas was added to it; and the mixture was allowed to stand two minutes. If the absorption were very considerable, more nitrous gas was added, till all the oxygen appeared to be absorbed. The residual gas was then transferred into a glass tube, two feet long, and one-third of an inch wide, graduated to tenths and hundredths of an ounce measure; and thus the quantity of oxygen absorbed was measured by the diminution that had taken place.

Von Humboldt proposes that the nitrous gas should be examined, before it is used, by agitating a given quantity with a solution of sulphate of iron.

Sir H. Davy employs the nitrous gas in a different manner. He passes it into a saturated solution of green muriate or sulphate of iron, which becomes opaque and almost black when fully impregnated with the gas. The air to be tried is contained in a small graduated tube, largest at the open end, which is introduced into the solution, and then gently inclined

toward the horizon, to accelerate the action, which will be complete in a few minutes, so as to have absorbed all the oxygen. He observes, that the measure must be taken as soon as this is done, otherwise the bulk of the air will be increased by a slow decomposition of the nitric acid formed.

Volta had recourse to the accension of hydrogen gas. For this purpose, two measures of hydrogen are introduced into a graduated tube with three of the air to be examined, and fired by the electric spark. The diminution of bulk, observed after the vessel had returned to its original temperature, divided by three, gives the quantity of oxygen consumed.

Phosphorus and sulphuret of potash have likewise been employed in eudiometry.

A piece of phosphorus may be introduced, by means of a glass rod, into a tube containing the air to be examined, standing over water, and suffered to remain till it has absorbed its oxygen; which, however, is a slow process. Or a glass tube may be filled with mercury and inverted, and a piece of phosphorus, dried with blotting paper, introduced, which will of course rise to the top. It is there to be melted, by bringing a red-hot iron near the glass, and the air to be admitted by little at a time. At each addition the phosphorus inflames; and, when the whole has been admitted, the red-hot iron may be applied again, to ensure the absorption of all the oxygen. In either of these modes 1 40th of the residuum is to be deducted, for the expansion of the nitrogen, by means of a little phosphorus which it affords.

Professor Hope of Edinburgh, employs a very convenient eudiometer, when sulphuret of potash, or Sir H. Davy's *liquid* is used. It consists of two glass vessels, one to hold the solution of sulphuret of potash, or other eudiometric liquor, about two inches in diameter, and three inches high, with a neck at the top as usual, and a tubulure, to be closed with a stopple in the side near the bottom: the other is a tube, about eight inches and a half long, with a neck ground to fit into that of the former. This being filled with the air to be examined, and its mouth covered with a flat piece of glass, is to be introduced under water, and there inserted into the mouth of the bottle. Taking them out of the water, and inclining them on one side they are to be well shaken, occasionally loosening the stopper in a basin filled with water, so as to admit this fluid to occupy the vacuum occasioned by the absorption. Bottles of much smaller size than here mentioned, which is calculated for public exhibition, may generally be employed; and, perhaps, a graduated tube, ground to fit into the neck of a small phial, without projecting within it, may be preferable on many occasions, loosening it a little under water, from time to time, as the absorption goes on.

EUPHORBIUM. A gum-resin exuding from a large oriental shrub, euphorbia officin. Linn.

It is brought to us immediately from Barbary, in drops of an irregular form; some of which upon being broken are found to contain little thorns, small twigs, flowers, and other vegetable matters; others are hollow, without any thing in their cavity: the tears in general are of a pale yellow colour externally, somewhat white withinside: they easily break betwixt the fingers. Specific gravity 1.124. Slightly applied to the tongue, they affect it with a very sharp biting taste; and, upon being held for some time in the mouth, prove vehemently acrimonious, inflaming and exulcerating the fauces, &c. Euphorbium is extremely troublesome to pulverize, the finer part of the powder, which flies off, affecting the head in a violent manner. The acrimony is so great, as to render it absolutely unfit for any internal use. It is much employed in the veterinary art as an epispastic:

The following constituents were found in euphorbium by Braconnot:

Resin	37.0
Wax	19.0
Malate of lime	20.5
Malate of potash	2.0
Water	5.0
Woody matter	13.5
Loss	3.0
	100.0

The resin is excessively acrid, and poisonous.

EXTRACT exists in almost all plants. It may be procured in a state of tolerable purity from saffron, by merely infusing it in water, and evaporating the solution. It may likewise be obtained from catechu, or *terra japonica*, a substance brought from India. This substance consists principally of astringent matter, and extract; by the action of water upon it, the astringent matter is first dissolved, and may be separated from the extract. Extract is always more or less coloured; it is soluble in alcohol and water, but not soluble in ether. It unites with alumina when that earth is boiled in a solution of extract; and it is precipitated by the salts of alumina, and by many metallic solutions, particularly the solution of muriate of tin.

From the products of its distillation, it seems to be composed principally of hydrogen, oxygen, carbon, and a little azote.

There appears to be almost as many varieties of extract as there are species of plants. The difference of their properties probably in many cases depends upon their being combined with small quantities of other vegetable principles, or to their containing different saline, alkaline, acid, or earthy ingredients. Many dyeing substances seem to be of the nature of extractive principle, such as the red colouring matter of madder, and the yellow dye, procured from weld.

Extract has a strong attraction for the fibres of cotton or linen, and combines with these substances when they are boiled in a solution of it. The combination is made stronger by the intervention of mordants, which are earthy or metallic combinations that unite to the cloth, and enable the colouring matter to adhere more strongly to its fibres.

Extract, in its pure form, cannot be used as an article of food, but it is probably nutritive when united to starch, mucilage, or sugar.

EYE. The humours of the eye have been scientifically examined by M. Chenevix. Most of his experiments were made with the eyes of sheep, as fresh as they could be obtained.

The aqueous humour is clear and transparent, without smell or taste. Specific gravity 1.009. It consists of water, albumen, gelatine, and muriate of soda.

The crystalline contains a much larger proportion of water, and no muriate; specific gravity 1.1.

The vitreous humour, when pressed through a rag to free it from capsules, is found to be the same with the aqueous humour, both as to specific gravity and its component parts. M. Chenevix could not discover any phosphate in these humours, which M. Fourcroy had supposed he had found.

The same products were found in the human eye, but the specific gravity of the crystalline humour was found to be 1.079, and of the aqueous and vitreous humours to be 1.0053.

The specific gravity of the crystalline humour of the eyes of oxen was found to be 1.0765, and of the other humours 1.0088.

The specific gravity of the crystalline humour gradually increases from the surface to the centre.

F

FAHLUNITE AUTOMALITE, a subspecies of octohedral corundum.

FARINA. Vegetable flour.

FAT. This animal product is composed of an oily substance,

which remains fluid at the ordinary state of the atmosphere, and another substance much less fusible. The first of these melts at 45°, and the second at 100°; and about twice as much of the first is soluble in alcohol as of the second. The oily substance is much more readily changed into soap by the addition of alkalis.

When fat is united with potass it is changed into three bodies, margarine, fluid fat, and the sweet principle; and this change is effected without the absorption of any foreign substance.

FÆCULA. See STARCH.

FELSPAR, OR FELDSPAR, is hard in a somewhat less degree than quartz and more easily broken. It is foliated or composed of thin lamina or plates, by which it may be generally distinguished from quartz. The crystals are most commonly four-sided, or six-sided prisms, whose length is greater than the breadth. It has a shining lustre.

The colours are white, gray, milk-white, yellowish or reddish-white, sometimes inclining to green. The red passes through various shades from a pale to a deep red. Crystallized felspar is translucent. It may be melted without the admixture of alkalis, and forms a glass more or less transparent, which quality it derives from the lime or alkali that compose part of the constituent ingredients, but different specimens vary, according to the analysis of the same chemist.

Silex	63	74
Alumina	17	14
Potash	13	0
Lime	3	6
Oxyd of iron	1	0
Loss	3	6

Others give the proportion of silex 46, alumina 24, lime 6.

The existence of potash, or the vegetable alkali, in felspar is a fact deserving particular attention, it may be owing to this circumstance that felspar is so frequently observed in a soft or decomposing state, although its hardness is little inferior to that of quartz when undecayed. Those felspars which are durable are probably free from potash. Felspar is sometimes uncrystallized and compact, in which state it is classed by the French mineralogists with petrosilex or horn-stone. It is fusible without the addition of alkalis.

This is one of the most abundant minerals, being the principle constituent part of granite and gneiss; it occurs in white-stone, syenite, and porphyries. Green-stone is a compound of felspar and hornblende. Under the name of petunze it is a chief ingredient in the Chinese porcelain. There are a great number of varieties of felspar enumerated by the mineralogists. There are, 1. *Adularia.* Colour greenish-white; iridescent; and in thin plates, pale flesh red by transmitted light. Its constituents are, 64 silica, 20 alumina, 2 lime, and 14 potash.—*Vauquelin.*

Under the name of moonstone it is worked by lapidaries. Another variety, from Siberia, is called sunstone by the jewellers. It is of a yellowish colour, and numberless golden spots appear distributed through its whole substance.

2. *Glassy felspar.* Colour greyish-white. Crystallized in broad rectangular four-sided prisms, bevelled on the extremities. Its constituents are, 68 silica, 15 alumina, 14.5 potash, and 0.5 oxide of iron.—*Klapr.* It occurs imbedded in pitch-stone porphyry in Arran and Rum.

3. *Ice-spar.* Colour greyish-white. Massive, cellular and porous; and crystallized in small, thin, longish six-sided tables.

4. *Common felspar.* Colours white and red, of various shades; rarely green and blue. Its constituents are as follows:

	Siberian green felspar.	Flesh-red felspar.	Felspar from Passau.
Silica,	62.83	66.75	60.25
Alumina,	17.02	17.50	22.00
Lime,	3.00	1.25	0.75
Potash,	13.00	12.00	14.00
Oxide of iron,	1.00	0.75	water, 1.00
	96.85	98.25	1.00
	Vauq.	*Rose.*	*Bucholz.*

5. *Labradore felspar.* Colour grey of various shades. When

light falls on it in certain directions, it exhibits a great variety of beautiful colours.

6. *Compact felspar.* Colours, white, grey, green and red. Its constituents are, 51, silica, 30.5 alumina, 11.25 lime, 1.75 iron, 4 soda, 1.25 water.

7. *Clinkstone;* which see.

8. *Earthy common felspar.* This seems to be disintegrated common felspar.

9. *Porcelain earth.* See CLAY.

Pyramidal felspar. See SCAPOLITE, and ELAOLITE.

Prismato-pyramidal felspar. See MEIONITE.

Rhomboidal felspar. See NEPHELINE.

FERMENTATION. By this term is understood a spontaneous motion, which is excited in vegetable or animal substances which totally changes their nature. Animal liquids alone, or mixed with vegetables, quickly become sour, and this is called acetous fermentation. But when a solution of saccharine matter, or saccharine matter and starch, or sweet juices of fruits suffer this change, the result is beer or wine, and the process is called a vinous fermentation. An ulterior change to which all moist animal and vegetable substances are liable, is called putrefactive fermentation. These processes go on most rapidly at a moderately high temperature.

As vegetables consist of carbon, oxygen, and hydrogen, and animal matter consists of these principles combined with azote, all the products of fermentation must be products of these three or four principles.

All vegetable substances containing saccharine matter is susceptible of vinous fermentation.

The liquor first becomes turbid and viscid; an intestine motion and increase of bulk gradually takes place; air bubbles are discharged from its whole mass, bursting forth with a perceptible noise, and forming a kind of froth or yeast. The sweetness of the fluid disappears, and a pungent taste is acquired. After a certain time, these phenomena cease, and the fluid deposits a copious sediment, and becomes again clear, bright, and transparent. It has acquired a brisk taste, a vinous odour, and an intoxicating quality. Wine is obtained from the expressed juice of the grape. The grapes are put into the wine press and squeezed, and the liquor obtained is put into a cask, where it is fermented; it is then drawn off and put into other casks, where a second though insensible fermentation goes on; and it is this change which causes the difference between *old* and *new* wine. Wine is the stronger in proportion to the quantity of saccharine matter contained in the grapes. By a similar process raisin wine, currant wine, gooseberry wine, and cider and perry may be obtained. The mode of obtaining ale and beer is already noticed under the article ALE.

According to Lavoisier 100 parts of sugar afford—

Alcohol	57.70
Carbonic acid . . .	35.34
	93.04

When it is required to preserve fermented liquors in the state produced by the first stage of fermentation, it is usual to put them into casks before the vinous process is completely ended: and in these closed vessels a change very slowly continues to be made for many months, and perhaps for some years.

But if the fermentative process be suffered to proceed in open vessels, more especially if the temperature be raised to 90 degrees, the acetous fermentation comes on. In this, the oxygen of the atmosphere is absorbed; and the more speedily in proportion as the surfaces of the liquor are often changed by lading it from one vessel to another. The usual method consists in exposing the fermented liquor to the air in open casks, the bunghole of which is covered with a tile to prevent the entrance of the rain. By the absorption of oxygen which takes place, the inflammable spirit becomes converted into an acid. If the liquid be then exposed to

distillation, pure vinegar comes over instead of ardent spirit.

When the spontaneous decomposition is suffered to proceed beyond the acetous process, the vinegar becomes viscid and foul; air is emitted with an offensive smell; volatile alkali flies off; an earthy sediment is deposited; and the remaining liquid, if any, is mere water. This is the putrefactive process.

The fermentation by which certain colouring matters are separated from vegetables, as in the preparation of woad and indigo, is carried much farther, approaching the putrefactive stage.

It is not clearly ascertained what the yeast or ferment performs in this operation. It seems probable, that the fermentative process, in considerable masses, would be carried on progressively from the surface downwards; and would, perhaps, be completed in one part before it had perfectly commenced in another, if the yeast, which is already in a state of fermentation, did not cause the process to begin in every part at once.

FERROCYANATES. The same as Ferroprussiate. See Prussic Acid.

FERROCYANIC ACID. The same as Ferroprussic Acid. See Prussic Acid.

FIBRIN is a peculiar organic compound found in vegetables and in animals. There are few vegetables from which this substance is obtained distinctly characterised, but it is found abundantly in all animals. It is found in the chyle, the blood, and the muscular flesh. If the blood from the veins be beaten with rods, long reddish filaments of fibrin will adhere to them, and if washed in cold water they will become colourless, and the matter of fibrin will be found to be solid, white, insipid, without colour and smell. When moist it is, in some degree, elastic; when dried it is yellow, hard, and brittle. By distillation it yields carbonate of ammonia, some acetate, brown oil, and gaseous products. There remains in the retort a charcoal, which, after combustion, leaves phosphate of lime, phosphate of magnesia, with carbonates of lime and soda.

Concentrated acetic acid softens it at an ordinary temperature, and with heat, converts it into jelly, soluble in hot water. Sulphuric, nitric, and muriatic acids, precipitate the animal matter and form acid products.

Aqueous potass and soda dissolve fibrin in cold water, without changing its nature; but with heat they produce ammoniacal gas and other usual animal products.

It is composed, according to M. Gay Lussac and Thenard, of—

Carbon	53.360
Azote	19.934
Oxygen	19.685
Hydrogen	7.021
	100.000

FIBROLITE is a mineral of a white and grey colour, consisting of alumina 58.25, silica 38, iron and loss 3.75. It is crystallized in rhomboidal prisms.

FIGURE STONE. See Agalmatolite.

FILTRATION. An operation, by means of which a fluid is mechanically separated from consistent particles merely mixed with it. It does not differ from straining.

An apparatus fitted up for this purpose is called a filter. The form of this is various, according to the intention of the operator. A piece of tow, or wool, or cotton, stuffed into the pipe of a funnel, will prevent the passage of grosser particles, and by that means render the fluid clearer which comes through. Spunge is still more effectual. A strip of linen rag wetted and hung over the side of a vessel containing a fluid, in such a manner as that one end of the rag may be immersed in the fluid, and the other end may remain without, below the surface, will act as a syphon, and carry over the clearer portion. Linen or woollen stuffs may either be fastened over the mouths of proper vessels, or fixed to a frame, like a sieve, for the purpose of filtering. All these are more commonly used by cooks and apothecaries than by philosophical chemists, who, for

the most part, use the paper called cap paper, made up without size.

As the filtration of considerable quantities of fluid could not be effected at once without breaking the filter of paper, it is found requisite to use a linen cloth, upon which the paper is applied and supported.

Precipitates and other pulverulent matters are collected more speedily by filtration than by subsidence. But there are many chemists who disclaim the use of this method, and avail themselves of the latter only, which is certainly more accurate, and liable to no objection, where the powders are such as will admit of edulcoration and drying in the open air.

Some fluids, as turbid water, may be purified by filtering through sand. A large earthen funnel, or stone bottle with the bottom beaten out, may have its neck loosely stopped with small stones, over which smaller may be placed, supporting layers of gravel increasing in fineness, and lastly covered to the depth of a few inches with fine sand, all thoroughly cleansed by washing. This apparatus is superior to a filtering stone, as it will cleanse water in large quantities, and may readily be renewed when the passage is obstructed, by taking out and washing the upper stratum of sand.

A filter for corrosive liquors may be constructed, on the same principles, of broken and pounded glass.

On board of ship, where economy of water is often an object of consideration, dirty water may easily be purified, so as to be fit again for washing. Let it be put into a large tub, and get another tub of a smaller size, with holes in the bottom, with sand and charcoal strewed on the bottom. If this tub be placed in the larger tub, the water will rise into it, and will be found clear.

FIRE. See CALORIC and COMBUSTION.

FIRE-DAMP. A name given by the miners to the gas which forms in the mines, and produces explosions. See CARBURETTED HYDROGEN GAS.

FIXATION OF GAS, this term has been introduced into the new system of matter and motion, to express the transfer of the motions, of the atoms composing gas, when condensed or solidified, by which heat is at the same time produced; for as the atoms of the gas part with their motion, or some of their motion, to the adjacent bodies, and heat is assumed to be atomic motion; so after such transfer, adjacent bodies exhibit *heat;* in the case of the fixation in the lungs of animals, *heat and muscular energy;* and in that of combustion, *heat and the radiation of light.* In each case the oxygenous atoms seem to produce these results, as they disappear during the operations; and the resulting heat is greater than the previous heat of the gaseous medium, owing to the concentration, and the acceleration by repetitions.

FIXED AIR. The name given by Dr. Black to carbonic acid gas. On account of its being fixed, or solidified in chalk.

FIXED OIL is obtained by expression from seeds and fruits; the olive, the almond, linseed and rape seed, afford the most common fixed oils. The properties of fixed oils are well known. Their specific gravity is less than that of water; that of olive and of rape-seed oil is 913; that of linseed and almond oil 932; that of palm oil 968; that of walnut and beech mast oil 923. Many of the fixed oils congeal at a lower temperature than that at which water freezes. They all require for their evaporation a higher temperature than that at which water boils. The products of the combustion of oil are water and carbonic acid gas.

From the experiment of Gay Lussac and Thenard, it appears that olive oil contains in 100 parts,

Carbon . .	77,213
Oxygen .	9.427
Hydrogen .	13,360

This estimation is a near approximation to 11 proportions of carbon, 20 hydrogen, and 1 oxygen.

The following is a list of fixed

oils, and of the trees that afford them.

Olive oil, from the olive tree (olea Europea), linseed oil, from the common and perennial flax (linum usitatissimum et perenne), nut oil, from the hazel nut (coryllus avellana), walnut (juglans regia), hemp oil, from the hemp (cannabis sativa), almond oil, from the sweet almond (amygdalus communis), beech oil, from the common beech (fagus sylvatica), rape-seed oil, from the rapes (brassica napus et campestris), poppy oil, from the poppy (papaver somniferum), oil of sesamum, from the sesamum (sesamum orientale), cucumber oil, from the gourds (cucurbita pepo et malapepo), oil of mustard, from the mustard (sinapis nigra et arvenis), oil of sunflower, from the annual and perennial sunflower, (helianthus annuus et perennis), castor oil, from the palma christi (ricinus communis), tobacco-seed oil, from the tobacco (nicotiana tabacum et rustica), plum kernel oil, from the plum tree (prunus domestica), grape-seed oil, from the vine (vitis vinifera), butter of cacoa, from the cacoa tree (theobroma cacao), laurel oil, from the sweet bay tree (laurus nobilis).

The fixed oils are very nutritive substances; they are of great importance in their applications to the purposes of life. Fixed oil, in combination with soda, forms the finest kind of hard soap. The fixed oils are used extensively in the mechanical arts, and for the preparation of pigments and varnishes.

FIXITY. The property of resisting the heat, so as not to rise in vapour.

FLAKEWHITE is an oxide of bismuth.

FLAME. See COMBUSTION.

FLESH. The flesh of animals is found to consist of fibrin, albumen, gelatin, extract, with phosphates of soda, ammonia, and lime, carbonate of lime, and sulphate of soda.

FLINT. This mineral consists of 98 silica, 0.50 lime, 0.25 alumina, 0.25 oxide of iron, 1.0 loss. Its principal use is for gun-flints, and it is also reduced to a powder, and used in the manufacture of porcelain and glass. In England flint is usually found in immense strata under beds of chalk. It has excited the curiosity of geologists to determine in what manner the nodules of this substance have come into the middle of calcareous rocks. It is supposed that the silicious earth may have permeated the lime, and afterwards been separated by chemical affinity, and collected in fissures in the cavities of the calcareous rock.

There are processes in nature by which flint is formed in fresh water, as silicious earth and stones, are found in the fresh-water formations near Paris.

According to Saussure, the loose sand near Messina and the gulph of Charybdis becomes gradually so consolidated in a few years, as to serve for mill-stones, which he attributes to the infiltration of a calcareous liquor from the sea: but it may be doubted whether this infiltrated liquor does not contain silex from the great hardness communicated to the stones. Instances are on record of coins found in flints.

We are not able by artificial means to dissolve silex in water; but we know that nature has the power of effecting it by some unknown process, from the silicious earth held in solution by the hot waters of Bath; and still more abundantly by the boiling waters of Iceland. Whether the earths are convertible into each other by natural processes we cannot ascertain; but as they are now known to consist of oxygen combined with metallic bases, and these bases are supposed to be compounds of simpler elements, it does not appear improbable that this change may take place: could the fact be established, many anomalous appearances in the mineral kingdom would admit of an easy explanation.

FLINTY-SLATE. This mineral differs from common slate by containing a greater portion of silicious earth. Slate and flinty slate pass into each other, and frequently alternate. There are two kinds of this mineral. Common flints, slate, and Lydian stone. The

first is of an ash grey colour, in flamed, striped, and spotted delineations; the second is of a greyish black, and passes into velvet black.

FLOATSTONE consists of 98 silica and 2 lime. It is called spongiform quartz by Jameson. Its colour is white of various shades. It is softer than quartz.

FLOUR. The powder produced by the grinding of grain, which is used for food.

FLOWERS. A general appellation used by the elder chemists, to denote all such bodies as have received a pulverulent form by sublimation.

FLOWERS OF VEGETABLES. The different parts of flowers contain different substances: the pollen, or impregnating dust of the date, has been found by Fourcroy and Vauquelin to contain a matter analogous to gluten, and a soluble extract abounding in malic acid. Link found in the pollen of the hazle tree much tannin and gluten.

Saccharine matter is found in the nectarium of flowers, or the receptacles within the corolla, and by tempting the larger insects into the flowers, it renders the work of impregnation more secure; for the pollen is often by their means applied to the stigma; and this is particularly the case when the male and female organs are in different flowers or different plants.

It has been stated, that the fragrance of flowers depends upon the volatile oils they contain; and these oils, by their constant evaporation, surround the flower with a kind of odorous atmosphere; which, at the same time that it entices larger insects, may probably preserve the parts of fructification from the ravages of smaller ones. Volatile oils, or odorous substances, seem particularly destructive to these minute insects and animalcules which feed on the substance of vegetables; thousands of aphides may be usually seen on the stalk and leaves of the rose; but none of them are ever observed on the flower. Camphor is used to preserve the collections of naturalists. The woods that contain aromatic oils are remarked for their indestructibility, and for their exemption from the attacks of insects: this is particularly the case with the cedar, rose-wood, and cypress. The gates of Constantinople, which were made of this last wood, stood entire from the time of Constantine, their founder, to that of Pope Eugene IV. a period of 1100 years.

The petals of many flowers afford saccharine and mucilaginous matter. The white lily yields mucilage abundantly; and the orange lily a mixture of mucilage and sugar; the petals of the convolvulus afford sugar, mucilage, and albuminous matter.

The chemical nature of the colouring matters of flowers has not as yet been subject to any very accurate observation. The colouring matters, in general, are very transient, particularly the blues and reds; alkalis change the colours of most flowers to green, and acids to red. An imitation of the colouring may be made by digesting solutions of gall nuts with chalk; a green fluid is obtained, which becomes red by the action of an acid, and has its green colour restored by means of alkalis.

The yellow colouring matters of flowers are the most permanent: the carthamus contains a red and a yellow colouring matter; the yellow colouring matter is easily dissolved by water, and from the red rouge is obtained by a process which is kept secret.

FLUATES. Compounds of the fluoric acid with earths, alkalis, and metallic oxides.

FLUIDITY. The state of bodies when their parts are readily moveable in all directions with respect to each other.

FLUOBORATES. Compound of the fluoboric acid and salifiable bases.

FLUOBORIC ACID is obtained by mixing fluor spar with dry vitreous boracic acid. See Fluoric Acid.

FLUOR. This spar may be divided into three species, compact, foliated, and earthy. The second species is most abundant, and is usually called in England, Derby

shire spar. Berzelius found its constituents to be 72.1 lime, and 27.9 fluoric acid. It is cut into a variety of ornamental forms. When two pieces are rubbed together in the dark they phosphoresce with a blue and green light. Sulphuric acid evolves fluoric fumes which corrode glass.

FLUORIC ACID is found in combination with calcareous earth, in Derbyshire spar. If the pure spar be placed in a retort of lead or silver, with a receiver of the same metal adapted, and its weight of sulphuric acid be then poured upon it, the fluoric acid will be disengaged with a moderate heat. This acid readily combines with water, for which purpose it is necessary that the receiver should be previously half filled with that fluid. This acid is very volatile. Its specific gravity is only 1.0609. It must be examined with great caution, and if applied to the skin, it causes painful wounds. With water, in a certain proportion, its density may be increased to 1.25. This acid attacks glass, and corrodes it; and it has been employed in etching figures on glass: the whole glass must be covered with a thin coating of wax, in which the figure is to be traced, so as to leave bare the parts intended to be acted upon. This acid consists of oxygen and its base fluor.

On being immersed in water and then dried it gained 2½ grains, but did not recover its lustre.

This acid combines with lime, and forms the fluor spar. It becomes phosphorescent by heat, but this property gradually is lost, and cannot be recovered. It decrepitates with a strong heat. At 130° of Wedgwood it enters into fusion in a clay crucible. It is not acted on by air, is insoluble in water; concentrated sulphuric acid aided by heat, decomposes it, and causes the acid to rise with effervescence. It is used for chimney ornaments.

Fluoric acid takes barytes from the nitric and muriatic acids, and forms a salt, which is little soluble, and effloresces in the air.

The fluate of potash is not crystallizable, its taste is acrid and saline. It melts with a strong heat, and is afterwards caustic.

The fluate of soda and ammonia may be obtained combined with silicious earth.

Ammonia and magnesia, according to Fourcroy, form a triple salt with fluoric acid.

Fluoric acid has been detected in topaz, in wavellite, and in fossil teeth, and fossil ivory.

FLUX. A general term made use of to denote any substance or mixture added to assist the fusion of minerals. In the large way, limestone and fusible spar are used as fluxes. The fluxes made use of in assays, or philosophical experiments, consist usually of alkalis, which render the earthy mixtures fusible, by converting them into glass; or else glass itself in powder.

Alkaline fluxes are either the crude flux, the white flux, or the black flux. Crude flux is a mixture of nitre and tartar, which is put into the crucible with the mineral intended to be fused. The detonation of the nitre with the inflammable matter of the tartar, is of service in some operations; though generally it is attended with inconvenience on account of the swelling of the materials, which may throw them out of the vessel, if proper care be not taken either to throw in only a little of the mixture at a time, or to provide a large vessel.

White flux is formed by projecting equal parts of a mixture of nitre and tartar, by moderate portions at a time, into an ignited crucible. In the detonation which ensues, the nitric acid is decomposed, and flies off with the tartaric acid, and the remainder consists of the potash in a state of considerable purity. This has been called fixed nitre.

Black flux differs from the preceding, in the proportion of its ingredients. In this the weight of the tartar is double that of the nitre; on which account the combustion is incomplete, and a considerable portion of the tartaric acid is decomposed by the mere heat, and leaves a quantity of coal behind, on which the black colour

depends. It is used where metallic ores are intended to be reduced, and effects this purpose, by combining with the oxygen of the oxide.

The advantage of M. Morveau's reducing flux, seems to depend on its containing no excess of alkali. It is made of eight parts of pulverized glass, one of calcined borax, and half a part of powder of charcoal. Care must be taken to use a glass which contains no lead. The white glasses contain in general a large proportion, and the green bottle glasses are not perhaps entirely free from it.

FOOD. Animal matters in general are safe articles of food. In regard to the higher classes, the mammalia and birds, this is universally true of those in a state of health. A few exceptions occur among the fishes, depending either upon the constitution of certain persons, who are injuriously affected by substances, generally alimentary; or upon some singularity in the nature of the individual fish by which it becomes poisonous, although the species is generally nutritious and wholesome. As we descend still lower in the scale, these exceptions occur more frequently, and more species are absolutely and universally, unwholesome, or furnish poisons hurtful to every constitution. In the vegetable kingdom, the alimentary vegetables form but a small proportion of the whole, and almost an equal number are absolutely poisonous, or at least injurious, except when given in small quantities, to counteract some existing disease.

Although quadrupeds, without exception, furnish articles which may be safely used as food, their flesh differs much in palatability, and probably in its nutritious qualities. There is also no part of this class of animals that may not be, and indeed is not occasionally, used as food, although the flesh, or voluntary muscles, upon the limbs, trunk, and head, is by far the most considerable and important. Also the milk of all quadrupeds is alimentary, and generally agree-

In general, the flesh and other parts are coarser in proportion to the size of the animal, not only when different in kind, but in different varieties of the same species, although well grown individuals of the same variety are always better than those which have not been sufficiently nourished.

The whole organs of young animals are much more gelatinous than those of the adult and aged, while these contain more fibrine and extract. Hence the flesh of young animals is more bland and tender, and yields most to the action of boiling water, while that of aged animals is more savoury, even to rankness, and is firm to toughness.

The sex also greatly influences the quality of the flesh, that of the female being always more delicate and fine grained than that of the entire male, of which the fibres are stronger and the taste more rank. Indeed, the influence of the genital organs on the flesh of animals is very remarkable. The delicacy of the flesh, even of the female, is greatly improved by removing the ovaries, or spaying them as it is called.

The manner in which the animal has been fed has also considerable influence on the quality of the flesh. Generally the lean of fat animals is better than that of those that are poor, and perhaps an animal in a state of nature can never be too fat. Artificial fattening may, however, be carried too far, and the practice of feeding oxen on oil-cake for the market is now almost laid aside, as the beef acquired from it an unpleasant rancidity.

The season of the year has considerable influence on the quality of butcher meat, though less than upon other kinds of aliment. Its influence depends upon the more or less plentiful supply of food; upon the periodical change which takes place in the body of the animal, and upon temperature. The flesh of most full grown quadrupeds is in highest season during the first months of winter, after having enjoyed the summ-

tage of the abundance of fresh summer food. Its flavour then begins to be injured by the turnips given as winter food, and in spring it gets lean from deficiency of food. Although beef and mutton are never absolutely out of season, or not fit for the table, they are best in November, December, and January. Pork is absolutely bad, or out of season, during the summer months, and is only good in those of winter. The males of the deer tribe are in highest season from the middle of June to the beginning of September, when they begin to rut, after which they become thin and exhausted. Females in general are out of condition when they are suckling, or have lately suckled or given milk.

The common mode of killing cattle in this kingdom is, by striking them on the forehead with a pole-axe, and then cutting their throats to bleed them. But this method is cruel and not free from danger. The animal is not always brought down by the first blow, and the repetition is difficult and uncertain; and if the animal be not very well secured, accidents may happen. Lord Somerville, therefore, endeavoured to introduce the method of pithing or laying cattle, by dividing the spinal marrow above the origin of the phrenic nerves, as is commonly practised in Barbary, Spain, Portugal, Jamaica, and in some parts of England; and Mr. Jackson says, that "the best method of killing a bullock, is by thrusting a sharp pointed knife into the spinal marrow, when the bullock will immediately fall without any struggle, then cut the arteries about the heart." Although the operation of pithing is not so difficult but it may, with some practice, be performed with tolerable certainty; and although Lord Somerville took a man with him to Portugal to be instructed in the method, and has made it a condition that the prize cattle shall be pithed instead of being knocked down; still pithing is not becoming general in Britain. This may be partly owing to prejudice; but we have been told that the flesh of the cattle killed in this way in Portugal is very dark, and becomes soon putrid, probably from the animal not bleeding well in consequence of the action of the heart being interrupted before the vessels of the neck are divided. It therefore seems preferable to bleed the animal to death directly, as is practised by the Jew butchers.

Calves, pigs, sheep, and lambs, are all killed by dividing at once the large vessels of the neck. Animals which are killed by accident, as by being drowned, hanged, or frozen, or by a fall, or ravenous animal, are not absolutely unwholesome. Indeed, they only differ from those killed methodically in not being bled, which is also the case with animals that are snared, and in those killed by hounds.

There is no bird, and no part of any bird, nor any bird's egg, which may not be safely used as food.

The manner in which birds are fed affects both their fatness and flavour. Birds seldom get very fat in their wild state, or when domesticated, if allowed to go at large. The art of fattening poultry consists in supplying them with abundance of healthy food, and confining them. Aquatic birds, ducks and geese in particular, must be prevented from going into the water, both because they never get fat, but also acquire a rancid fishy taste.

The fattening of fowls for the London market is a considerable branch of rural economy in some convenient situations. "They are put up in a dark place, and *crammed* with a paste made of barley meal, mutton suet, and some treacle or coarse sugar, mixed with milk, and are found to be completely ripe in a fortnight. If kept longer, the fever that is induced by this continued state of repletion renders them red and unsaleable, and frequently kills them." But fowls brought to this state of artificial obesity are never so well flavoured in the flesh, and probably not so salubrious as those

of the same species, fattened in a more natural way. The great secret of having fine pullets is cleanliness, and high keeping with the best corn.

Epicures, in all ages, have been exceedingly whimsical in the selection of certain parts of particular birds as dainties, and the ancients more so than the moderns; for although we still prize the combs of the common fowl, the trail of the woodcock, and even collect with care the dreg which drops from it in the process of roasting; the guts of the bustard, the gizzard and liver of the goose, and the feet of the duck;—we find that Roman epicures delighted in the brains of ostriches and parrots, the tongue of the flamingo, and the enlarged liver of the goose. The last still continues among our contiental neighbours to be in great request, and the providing them is a considerable branch of rural economy in some provinces.

The process followed in different parts of France is described at length by Sonnini: "The object of the third method is to enlarge the liver. Nobody is ignorant of the endeavours of sensuality to cause the whole vital forces to be determined towards this part of the animal, by giving it a kind of hepatic cachexy. In Alsace, the individual buys a lean goose, which he shuts up in a small box of fir, so tight that it cannot turn in it. The bottom is furnished with a wide grating of rods, for the passage of the dung. In the fore part there is a hole for the head, and below it a small trough is kept always full of water, in which some pieces of wood charcoal are left to steep. A bushel of maize is sufficient to feed it during a month, at the end of which time the goose is sufficiently fattened. A thirtieth part is soaked in water each night, and crammed down its throat next day, morning and evening. The rest of the time it drinks and guggles in the water. Towards the 22d day, they mix with the maize some poppy oil, and, at the end of the month, it is known by a lump of fat under each wing, or rather by the difficulty of breathing, that it is time to kill it, otherwise it will die of fat. The liver is then found weighing one or two pounds, and, besides, the animal is excellent for the table, and furnishes, during its roasting, from three to five pounds of fat, which is used in the cookery of vegetables."

Of the reptiles very few are used as food, though probably rather on account of their disgusting appearance, than of their being hurtful, or even unpalatable, as some of the greatest luxuries of the table belong to this class of animals. Besides the green turtle, several other species of testudo are eaten, especially the Græca, Europæa, and ferox. Of the lizards, the dracæna, Amboinensis, agilis, and iguana are eaten. The flesh of the last is said to be delicious, but unwholesome, especially to those affected with syphilis, which, however, is probably a vulgar prejudice. The lacerta scincus is held in estimation by the natives of the east, as aphrodisiac. The eggs of the iguana, and of most species of testudo, even of those whose flesh is said to be bad, as of the imbricata, are nutritious and agreeable. The flesh of the coluber natrix is eaten in some places; and even the viper, whose bite is poisonous, furnishes a nutritious broth to invalids. Of the frogs, the rana esculenta is a favourite article of food with our continental neighbours. The rana taurina, or bullfrog, rivals the turtle in the opinion of our transatlantic descendants. The rana bombina, though a toad, is also eaten in some places as a fish.

In some places, fish constitutes the sole or chief food of the people, hence called Ichthyophagi, and almost everywhere it is in request. In Siberia, dried fish is used instead of bread. The Laplanders make a bread of fish bones, and the Negroes of the west coast of Africa dry a species of sprat, and beat it in wooden mortars to a paste, which keeps all the year, and is eaten with rice or corn.

The subject of poisonous fishes is still involved in great obscurity, although so important to those exposed to suffer from them. It is not peculiar to any genus, species, or distinct variety, but occurs in individuals only, and those of several genera of very different classes. A fish is suspected when it is of an unusually large size, or is destitute of the natural fishy smell, or has black teeth; or when silver or an onion boiled along with it becomes black. But all these tests are uncertain. The poisonous quality is also said to be destroyed by salting the fish, or drinking along with it sea water, or the ripe juice of the lime, sugar cane, or sweet potatoe.

To improve the quality of fish they are sometimes subjected to the process called crimping. It has been examined by Mr. Carlisle, to whom we are indebted for the following facts: "Whenever the rigid contractions of death have not taken place, this process may be practised with success. The sea fish destined for crimping are usually struck on the head when caught, which it is said protracts the term of this capability, and the muscles which retain this property longest are those about the head. Many transverse sections of the muscles being made, and the fish immersed in cold water, the contractions called crimping take place in about five minutes, but, if the mass be large, it often requires thirty minutes to complete the process." The crimping of fresh water fishes is said to require hard water, and the London fishmongers usually employ it. Mr. Carlisle found that, by being crimped, the muscles subjected to the process have both their absolute weight and their specific gravity increased; so that it appears, that water is absorbed, and condensation takes place. It was also observed, that the effect was greater in proportion to the vivaciousness of the fish. From these observations it appears, that the object of crimping is first to retard the natural stiffening of the muscles, and then, by the sudden application of cold water, to excite it in the greatest possible degree, by which means it both acquires the desired firmness, and keeps longer. We may also here observe, that rigidity is a certain mark that the fish is perfectly fresh, and has not begun to spoil.

The mollusci do not furnish a very extensive scource of human food, and they are not without danger. Of those without shells, only the sepiæ and some ascideæ are eaten, but not generally. The limpet, patella vulgata; the periwinkle, turbo littoreus; and whelk, murex antiquus; are eaten, boiled, by the common people in this country; and the helix pomatia is reared and fattened with great care in some cantons of Swisserland, as an article of luxury, and exported pickled. Many other snails are eaten by the poor in various districts, and we do not know that any is absolutely hurtful.' The bivalves, in like manner, are generally wholesome, and some of them have long been among the deliciæ gulosorum. The Romans sent to Britain for oysters; and the British epicures delight in the pholas dactylus of the Italian shores.

The crustaceous shell-fish of sufficient size are very generally esculent, and some of them are greatly esteemed, and others abundant. These chiefly belong to the family of Cancer, and comprehend both short-tailed and long tailed species, the velvet crab, one of the most esteemed in France, the C. maenas, eaten by the poor in London. C. pagurus, the black-toed crab; C. ruricola, the land crab of our transatlantic islands; C. gammarus, the lobster; C. astacus, the craw fish; C. crangon, the shrimp; and C. squilla, the prawn; besides others not known in this country.

Few insects are used in food. The locust is, however, consumed in great quantities, both fresh and salted, so as to afford some compensation for the ravages it commits

Although the vegetable kingdom furnishes the human race, even those who eat flesh most freely,

with the greater part of their food, yet there are many more exceptions to the fitness for human food in the vegetable than in the animal kingdom, both from mere indigestibility or defect of nutritious qualities, and from being directly deleterious and hurtful. The selection of vegetable food, when we depart from that which is familiar and known, is, therefore, more difficult, and subject to uncertainty.

All parts of vegetables are used as food,—roots, stalks, or shoots,—leaves, flowers, fruits, seeds, and the whole plant. The seeds of the cerealia, the gramineæ of modern botanists, furnish the most important part of our food in almost every climate.

Preservation.—As the supply of food is always subject to irregularities, the preservation of the excess obtained at one time to meet the deficiency of another would soon engage the attention of mankind.

In general, organic substances, as soon as they are deprived of life, begin to undergo certain chemical changes, more or less rapidly, and of different kinds according to their nature. Although the modes of change, especially in the first stages, are almost as numerous as the substances themselves, yet ultimately, they terminate in one or more of the principal kinds of fermentation described by chemists. To each of these, besides the presence of an organic substance capable of undergoing it, several conditions are requisite, of which the principal are a certain temperature, a certain degree of moisture, and the access of air; and it is by obviating or modifying these conditions that we are enabled to prevent or regulate the natural fermentation. The kind of fermentation which substances undergo depends upon their composition, and it may be generally remarked, that those which do not contain a considerable proportion of azote are capable of the putrefactive fermentation, but pass through the vinous, acetous, and destructive, successively. On the other hand, those which contain a large proportion of azote are capable only of the putrefactive and destructive; but there are many substances containing a small proportion of azote, in which both kinds of fermentation are combined.

A great proportion of vegetables are used in a recent state, and, in this case, the sooner after they are gathered the better. Vegetables, in general, should be kept apart, for, if laid in contact, in a very short time they impart their peculiar flavours to each other. Leeks or celery will quickly spoil a whole basketful of cauliflower or the finer vegetables. Another general rule is, that they should not be kept in water, nor even washed or refreshed by sprinkling them with water, till they are to be used, as the flavour is thereby greatly injured; but if, by having been cut or gathered some time, they have become flaccid, it is absolutely necessary to restore their crispness before cooking them, otherwise they will be tough and unpleasant. This is to be done, when the size of the vegetable admits of it, as cauliflower, sallad, celery, &c. by cutting off a piece of the stalk and setting the fresh surface, thus exposed, in water, which will be absorbed; in other cases the whole vegetable must be immersed in water.

Succulent vegetables should be kept in a cool, shady, and damp place. They should also be kept in a heap and not spread out, which greatly influences their shrivelling. But when accumulated in too large heaps for any length of time, they are injured in another way, by their heating, as it is called, which is the commencement, in them, of a chemical change, or fermentation, which altogether alters their nature. In many cases the chief business is to prevent evaporation. Potatoes, turnips, carrots, and similar roots, intended to be stored up, should never be cleansed from the earth adhering to them, because the little fibres, by which it is retained, are thus wounded, and the evaporating surface is increased. They

should also be wounded as little as possible, and the tops of turnips and carrots should be cut off close to, but above, the root. The next thing to be attended to is to protect them from the action of the air and of frost. This is done by laying them in heaps, burying them in sand, or in earth, immersing them in water, or covering them with straw or mats. The action of frost is most destructive, as, if it be considerable, the life of the vegetable is destroyed, and it speedily rots. A less degree of frost induces a singular but hurtful change upon the potato, by converting part of its starch, or mucilage, into sugar. The germination of seeds also convert their starch into sugar, as is exemplified in the malting of barley. But, even after this change has been induced, if the substance be thoroughly dried in a kiln or otherwise, it will still remain a long time without decay.

The maturation of fruits, although not thoroughly examined, seems to be a change of the same kind; that is, sugar is formed at the expense of the other principle of the unripe fruit. The art of preserving fruits consists in being able to prevent and retard these changes. A certain proportion of moisture seems to be necessary for their decay; and hence, by careful exsiccation, grapes are converted into raisins, plumbs into prunes, and figs are dried. But by carefully excluding them from the air, they may even be preserved without dissipating their natural moisture. Thus currants, cherries, and damsons, gathered perfectly dry and sound, may be put into bottles, closed with cork and rosin, and buried in a trench, with the cork downwards. Fine bunches of grapes may also be preserved in bags, by closing the cut end of the stalk with wax, which prevents the escape of moisture, or they may be packed in very dry bran or sand. Some may even be preserved by being kept immersed in water. This is constantly practised in regard to the cranberry, and sometimes succeeds with apples.

Animal substances, in general, when deprived of life, have a natural tendency to undergo the putrefactive fermentation. Before this is established, they pass through a series of successive changes, which are intimately connected with our subject. After death, the bodies of animals cool more or less rapidly, according to the temperature and conducting power of the air, or other substances with which they are in contact. In fact, they do not differ in this respect from an equal mass of any other matter, heated artificially to the same temperature, and having the same conducting power. As this, however, is very weak, the bodies of animals cool very slowly after death.

After the irritability has entirely ceased, the muscles begin to become rigid, first those of the trunk, and then those of the limbs. Its duration is inversely as the time of its commencement; and it is longest of beginning, but is greatest and lasts longest in those animals which are suddenly killed when in high health. It appears very quickly, and lasts a short time only, in animals which die of exhaustion, or from fatigue. In whatever attitude the limbs are placed at its commencement, they continue; and hence butchers take care to dress properly the carcases of animals while yet supple. For after rigidity has commenced, if the position of the limb be forcibly changed, it is destroyed, and the joint becomes permanently supple. Also muscles which are frozen when rigid, are extremely supple as soon as they are thawed. Rigidity is perhaps never developed in animals frozen to death.

While this rigidity continues, the flesh of animals is hard and stringy, and, so far as the palate is concerned, not yet fit for the table, although fully nutritious, and in perfection for making soup. After the rigidity has totally ceased, animal flesh is not long of experiencing the commencement of those chemical changes, which terminate in putrefaction; and it is of the utmost importance, in domestic economy, to take care that all

large joints be in this intermediate state when they are cooked; for no skill in the culinary art will compensate for negligence in this point, as every one must have often experienced to his great disappointment. Meat, in which we are able to detect the slightest trace of putrescency, has reached its greatest degree of tenderness, and should be used without delay; but before this period, which in some kinds of meat is offensive, the degree of inteneration may be known by its yielding readily to the pressure of the finger, and by its opposing little resistance to an attempt to bend the joint. Poultry also thus part readily with their feathers, and it would be advisable to leave a few when the bird is plucked, in order to assist in determining their state.

The chief means of preventing the fermentation of organic substances are reduction of temperature, desiccation, exclusion of air, and the action of certain substances called antiseptic. Although most commonly employed in combination with each other, we shall briefly explain the principles upon which they act singly, and then notice their practical application in reference to the animal and vegetable kingdoms.

A moderate reduction of temperature acts by retarding vital and chemical action, and a reduction, capable of freezing the juices and fluids of organized bodies, by destroying vitality, and converting the water present into ice, and thus removing a condition essential to chemical action.

On dead organic substances, a reduced temperature acts by retarding or preventing chemical change.

The preservative effects of cold are of the utmost importance to the northern nations, by enabling them to store up a sufficient stock of all manner of provisions for their winter consumption, and to receive supplies from a great distance. It is thus, that veal frozen at Archangel is brought to Petersburgh, and the markets of Moscow present immense stocks of hogs, sheep, and fish. The same advantage is taken of the cold in Canada, and all other countries where the frost is sufficiently steady.

Some attention is necessary for thawing provisions which have been frozen. "When used, the beef cannot be divided but by an axe or a saw; the latter instrument is generally preferred. It is then put into cold water, from which it derives heat by the formation of ice around it, and soon thaws; but if put into hot water, much of the gravy is extracted, and the meat is injured without being thawed more readily. If an attempt be made to cook it before it is thawed, it may be burnt on the outside, while the centre remains raw, or actually in a frozen state." These observations, which we have transcribed from Captain Scoresby, an excellent observer, agree with the directions of earlier writers. Thus Krunitz says, (*Encyclop.* vol. x. p. 586,) "when fish taken under the ice are frozen, lay them in cold water, which thus draws the ice out of the fish, so that it can be scraped off their scales. They taste much better afterwards than when they are allowed to thaw in a warm room." We do not know whether it be ignorance or inattention to this direction on the part of the London fishmongers which causes the salmon sent from Scotland in ice to be little esteemed.

The second general method of preventing fermentation is desiccation, or the removal of that degree of moisture which is an essential condition to this kind of chemical action. Desiccation takes place in consequence of the air absorbing the moisture of bodies exposed to its action.

Gay Lussac found that neither fresh vegetable juices nor animal matter fermented so long as oxygen gas was perfectly excluded; and that the fermentation, in both cases, commenced as soon as any portion of oxygen was admitted. When oxygen gas is confined in contact with a fermentable substance, it is changed into an equal bulk of carbonic acid gas, and all farther action ceases. Methods

of preserving fermentable substances, illustrative of this principle, have long been practised imperfectly by housewives. Nothing can be simpler than Mr. Raffald's receipt for preserving green peas, cranberries, currants, &c. "Put them into dry clean bottles, cork them close, and tie them with a bladder; keep them in a cool dry place." A variation of this process was to fill the bottles previously with sulphurous acid vapour, by holding in them for some time a lighted sulphur match. One effect of this is to remove all uncombined oxygen. Other methods of excluding air were also employed, as filling up the interstices with water or melted suet. The success of this process was greatly promoted by subjecting the substances to the action of a certain degree of heat, after being put into the bottles or jars in which they were to be preserved; and then we are desired "to set them in a copper of hot water till they are hot quite through," or to "put them in an oven when the bread is drawn, and let them stand till shrunk a quarter part."

Animal substances have also long been occasionally preserved by the mere exclusion of air. The most familiar example is the buttering of eggs, which has the effect of closing the pores in the shell by which the communication of the embryo with the external air takes place. It is best performed by rubbing over the shell with butter while it is still warm after being laid; and an egg in this way retains the curdy milk, and possesses all the properties of a new laid egg for a great length of time; but at whatever period after being laid the egg is buttered over, its progress to decay seems to be arrested. The same effect is produced, though not so perfectly, by immersing eggs in water. From an experiment of Reaumur's, it appears that, the cutting off the access of air to the embryo in the egg, does not kill it, or prevent it from being hatched, but, on the contrary, preserves it alive for a much greater time than if it had not been treated in this manner. He covered over eggs with spirit varnish, and he found them capable of producing chickens after two years, when the varnish was carefully removed.

Although, however, the preservation of alimentary matters by the total exclusion of air, assisted by subjecting them to a certain degree of heat, has long been practised in some degree, we are certainly indebted to M. Appert, who first published in 1810, for the regular and scientific application of these principles upon a large scale. From extensive experience and long perseverance he became convinced,

"*1st*, That fire has the peculiar property, not only of changing the combination of the constituent parts of vegetable and animal productions, but also of retarding, for many years at least, if not of destroying, the natural tendency of those same productions to decomposition.

"*2dly*, That the application of fire in a manner variously adapted to various substances, after having, with the utmost care, and as completely as possible, deprived them of all contact with the air, effects a perfect preservation of those same productions, with all their natural qualities."

Upon these principles he invented many processes adapted to the different natures of the substances to be preserved, but the fundamental conditions consist, *1st*, In inclosing in bottles the substances to be preserved. *2dly*, In corking the bottles with the utmost care; for it is chiefly on the corking that the success of the process depends. *3dly*, In submitting these inclosed cases to the action of boiling water in a water-bath (*balneum mariæ*,) for a greater or less length of time, according to their nature, and in the manner pointed out with respect to each several kind of substance. *4thly*, In withdrawing the bottles from the water bath at the period described.

M. Appert employed at first bottles made of glass, which it was difficult to close exactly, especially when their mouths were large; but

he now uses cylinders of tin plate, which are soldered up after they are filled. This is especially an improvement for animal substances, which require much more attention than vegetables. Tin cases, or canisters, seem to have been first used in London by Messrs. Donkin and Gamble, by whom a very ingenious method of testing the provisions put up by them was also invented as early as 1813. The substances to be preserved are first parboiled or somewhat more. The vegetables and meat, the bones being removed, are then put into tin cylinders, which are filled up with the broth and the lid soldered down. It now undergoes the remainder of the cooking, when a small hole is opened at the top of the cylinder, and immediately closed with solder while still hot. The whole is now allowed to cool, and from the diminution of volume in the contents, in consequence of the reduction of temperature, both ends of the cylinder are pressed inwards and become concave. The cases thus hermetically sealed, are exposed in a *test-chamber* for at least a month, to a temperature above what they are ever likely to encounter; from 90° to 110° Fahrenheit. If the process has failed, putrefaction takes place, and gas is evolved, which in process of time will bulge out both ends of the case, so as to render them convex instead of concave. But the contents of whatever cases stand this test, will infallibly keep perfectly sweet and good in any climate, and for any length of time. Another advantage is, that if there be any taint about the meat when put up, it inevitably ferments, and is detected in the proving.

All kinds of alimentary matters may be preserved in this way,—beef, mutton, veal, and poultry, boiled and roasted; soups, broths, and vegetables, creams, and custards.

The salting may be performed either by dry rubbing, or by immersing the meat in pickle. Cured in the former way, the meat will keep longer, but it is more altered in its valuable properties; in the latter way it is more delicate and nutritious. Six pounds of salt, one pound of sugar, and four ounces of saltpetre, boiled with four gallons of water, skimmed and allowed to cool, forms a very strong pickle, which will preserve any meat completely immersed in it. To effect this, which is essential, either a heavy board, or flat stone, must be laid upon the meat. The same pickle may be used repeatedly, provided it be boiled up occasionally with additional salt to restore its strength, diminished by the combination of part of the salt with the meat, and by the dilution of the pickle by the juices of the meat extracted. By boiling, the albumen, which would cause the pickle to spoil, is coagulated, and rises in the form of scum, which must be carefully removed.

Dry salting is performed by rubbing the surface of the meat all over with salt; and it is generally believed that the process of salting is promoted if the salt be rubbed in with a heavy hand.

Fish, in like manner, may be preserved either by dry salting or in pickle. The former method is employed to a great extent on the banks of Newfoundland, and in Shetland.

The Dutch derive great national advantages from the preference given to the herrings caught upon our own coasts, when cured by them. They use no other than the Spanish or Portuguese salt, preserve no fish that they are not able to cure between sunrise, when the nets are drawn, and sunset, when they are again shot; and pay particular attention in gutting, sorting, and packing each kind by itself. They fill up the barrels with fish of the same kind and night's catching, and are exceedingly careful of the pickle, as they use no other in filling of the barrels. (*Highland Society's Transactions*, vol. ii. p. 321.)

Herrings and salmon are also often cured by drying them in wood smoke, after being slightly salted, and are called red herrings, or Yarmouth herrings, and kipper, or smoked salmon.

Butter is commonly preserved by working into each pound one or two ounces of salt, until they be thoroughly incorporated. The best salt for the purpose is in large crystals, and it should be thoroughly dried and coarsely powdered. But Dr. Anderson recommends for the curing of butter, a mixture of two parts of the best great salt, one of sugar, and one of saltpetre, beat into a fine powder. One ounce of this mixture is sufficient for a pound of butter. He says that butter cured in this way does not taste well till it has stood at least a fortnight after being salted, but after that period it has a rich marrowy taste, that no other butter ever acquires, and tastes so little salt, that one would imagine it would not keep; and yet Dr. Anderson has seen it perfectly sound and sweet when two years old.

Vinegar is never used for the preservation of butcher meat, but salmon is often pickled in it, with the addition of salt and spices.

Pyrolignic acid has lately been much extolled, as having a specific power in preserving animal matters.

The preservation of these by means of sugar constitutes a principal part of the art of confectionary, and attention to many minutiæ is necessary for the success of each preparation. The most general principles only can be noticed here.

Vegetable substances may be either preserved in syrup or candied; or their juices may be employed in making syrups, jellies, or fruit-cakes. The art of confectionary is very difficult, and to attain perfect success, requires attention to many particulars which at first seem frivolous and even improper, but which have been found by experience to be essential.

Sugar is equally powerful in preserving animal substances from putrefaction.

Other methods of preserving food have been tried, but rather as a matter of curiosity than utility.

The property of charcoal, to restore sweetness to flesh beginning to be tainted, was first pointed out by M. Lowitz in Petersburgh, in 1786 (*Crell's Annals*,) who made numerous experiments upon the subject. For their success, it is necessary that the charcoal have been recently burnt, and that it be applied in a certain quantity. Too little fails in its effect, and too much affects the nature of the substance upon which it acts. By some it has been supposed to act merely mechanically, by absorbing fluid and putrescent exudations; but it is more probable, that it acts chemically, by absorbing oxygen gas from the air in contact with the meat.

FORGE FURNACE. The forge furnace consists of a hearth, upon which a fire may be made, and urged by the action of a large pair of double bellows, the nozzle of which is inserted through a wall or parapet constructed for that purpose.

Black-lead pots, or small furnaces of every desired form, may be placed, as occasions require, upon the hearth; and the tube of the bellows being inserted into a hole in the bottom of the furnace, it becomes easy to urge the heat to almost any degree required.

FORMATIONS. The rocks and other solid arrangements of matter, of which the globe is composed, are considered by geologists, as having been formed at different times; and hence, they speak of older and later *formations*, limestone formations, sand-stone formations, and such like.

FORMIATES. Compounds of the formic acid with earths, alkalis, and metallic oxides.

FORMIC ACID is obtained from ants, either by simple distillation, or by infusing them in hot water, and afterwards distilling. It may afterwards be purified by repeated rectification, or it may be done in time of frost. This acid has been employed by quacks to relieve the pain of the tooth-ache. It has a very sour taste, and remains liquid at a low temperature. Specific gravity at 68° is 1.1168.

FOSSIL COPAL, OR HIGHGATE RESIN was found in a bed of blue clay, at Highgate, in the excavations for making the tunnel. It is

of a pale yellow. When heated, it gives out a resinous aromatic odour, melts into a limpid fluid, takes fire at a candle, and is entirely consumed before the blowpipe.

FOSSIL REMAINS, sometimes called ORGANIC REMAINS, and by Mr. Parkinson the *Remains of a former World*: in truth, however, merely the remains of vegetables and animals, which have been involved within earthy aggregates during the changes of position and composition, to which they are subject from the action of water and air, and from their mutual actions on each other. Having discussed the origin and formation of these curiosities of antiquity, under the titles *Surface of the Earth*, *Petrifaction*, *Strata*, &c. &c., it will be interesting to the reader to see in one point of view, a few of the most remarkable facts which have been given to the world, relative to the discovery of these remains.

Fossil crocodiles were collected in the neighbourhood of Honfleur, by the Abbé Bachelet, an assiduous naturalist at Rouen, and were sent, by orders of the prefect of the department, to the Museum of Natural History! Similar fossils are also obtained at Havre. They were found in a bed of hard limestone, of a bluish grey colour, which becomes nearly black when wet, and which is found along the shore, on both sides of the mouth of the Seine, being in some places covered by the sea, and in others above its level, even at high water.

Remains of crocodiles have also been found in other parts of France; as, at Angers and Mans. Some of these remains seem to show, that at least one of the fossil species above noticed is also found in other parts of France besides Honfleur and Havre.

The remains of crocodiles have been also found in different parts of England; but particularly on the coast of Dorsetshire, and of Yorkshire, near Whitby; in the neighbourhood of Bath; and near Newark, in Nottinghamshire.

Somersetshire, particularly in the neighbourhood of Bath; the cliffs on the Dorsetshire, or southern coast; and on the Yorkshire, or northern coast; are the places in this island in which the remains of the animals of this tribe have been chiefly found. The matrix in which they are found is in general similar to that which has been already mentioned as containing the fossils of Honfleur and Havre,—a blue limestone, becoming almost black when wetted. This description exactly agrees with the limestone of Charmouth, Lime, &c. in Dorsetshire; on the opposite coast to that of France, on which Havre and Honfleur are situated. At Whitby and Scarborough, where these fossils are also found, the stone is indeed somewhat darker than in the former places; but no difference is observable which can be regarded as offering any forcible opposition to the probability of the original identity of this stratum, which is observed on the northern coast of France, on the opposite southern English coast, and at the opposite northern extremity of the island. Some of these remains are also found in quarries of common coarse grey and whitish limestone. Instances of this kind of matrix, for these remains, are observable in the quarries between Bath and Bristol.

The Rev. Mr. Hawker, of Woodchester, in Gloucestershire, possesses perhaps, one of the handsomest specimens of the remains of the crocodile that has been found in this island. It was found by him in the neighbourhood of Bath, and contains great part of the head and of the trunk of the animal.

The large animal, whose fossil remains are found in *the quarries of Maestricht*, has been deservedly a frequent object of admiration; and the beautiful appearance which its remains possess, in consequence of their excellent state of preservation, in a matrix which admits of their fair display, has occasioned every specimen of this fossil to be highly valued. The lower jaw of this animal, with some other specimens which were presented by Dr. Peter Camper to

the Royal Society, and which are now in the British Museum, are among the most splendid and interesting fossils in existence.

In 1770, the workmen, having discovered part of an enormous head of an animal imbedded in the solid stone, in one of the subterranean passages of the mountain, gave information to M. Hoffman, who, with the most zealous assiduity, laboured until he had disengaged this astonishing fossil from its matrix. But, when this was done, the fruits of his labours were wrested from him by an ecclesiastic, who claimed it as being proprietor of the land over the spot on which it was found. Hoffman defended his right in a court of justice; but the influence of the Chapter was employed against him, and he was doomed, not only to the loss of this inestimable fossil, but to the payment of heavy law expenses. But in time, justice, M. Faujus says, though tardy, at last arrived—the troops of the French Republic secured this treasure, which was conveyed to the National Museum.

The length of the cervical, dorsal, and lumbar vertebræ, appears to have been about nine feet five inches, and that of the vertebræ of the tail about ten feet; adding to which the length of the head, which may be reckoned, considering the loss of the intermaxillary bones, at least at four feet, we may safely conclude the whole length of the skeleton of the animal to have approached very nearly to twenty-four feet.

The head is a sixth of the whole length of the animal; a proportion approaching very near to that of the crocodile, but differing much from that of the monitor, the head of which animal forms hardly a twelfth part of the whole length.

The tail must have been very strong, and its width at its extremity must have rendered it a most powerful oar, and have enabled the animal to have opposed the most agitated waters, as has been well remarked by M. Adrien Camper. From this circumstance, and from the other remains which accompany those of this animal, there can be no doubt of its having been an inhabitant of the ocean.

Taking all these circumstances into consideration, M. Cuvier concludes, and certainly on fair, if not indisputable grounds, that this animal must have formed an intermediate genus between those animals of the lizard tribe, which have an extensive and forked tongue, which include the monitors and the common lizards, and those which have a short tongue, and the palate armed with teeth, which comprise the iguanas, marbres, and anolis. This genus, he thinks, could only have been allied to the crocodile by the general characters of the lizards.

Fossil remains of Ruminantia.—Among the fossils of the British empire, none are more calculated to excite astonishment than *the enormous stags' horns* which have been dug up in different parts of Ireland.

Their dimensions, Dr. Molyneux informs us, were as follows:

	Feet.	*In.*
From the extreme tip of each horn . . .	10	10
From the tip of the right horn to its root	5	2
From the tip of one of the inner branches to the tip of the opposite branch .	3	7½
The length of one of the palms, within the branches . .	2	6
The breadth of the same palm, within the branches . .	1	10½
The length of the right brow antler . . .	1	2

A similar pair, found ten feet under ground, in the county Clare, was presented to Charles the Second, and placed in the horn gallery, Hampton-court, but was afterwards removed into the guard room of the same palace.

At Ballyward, near Ballyshannon; at Turvy, eight miles from Dublin; and at Portumery, near the river Shannon, in the county of Galway; similar horns have been found. In the common-hall

of the Bishop of Armagh's house, in Dublin, was a forehead, with two amazing large beams of a pair of this kind of horns, which, from the magnitude of the beams, must have much exceeded in size those of which the dimensions are given above. Dr. Molyneux states, that, in the last twenty years, thirty pair of these horns had been dug up by accident in this country; the observations, also, of several other persons, prove the great frequency with which these remains have been found in Ireland.

Various opinions have been entertained respecting this animal and its existing prototype. This, however, does not appear to have been yet discovered; and these remains may, I believe, be regarded as having belonged to an animal now extinct.

Numerous remains of *elephants* have been found in Italy; and, although a very considerable number of elephants were brought from Africa into Italy, yet the vast extent through which these remains have been found, and the great probability that the Italians, particularly the Romans, would have known sufficiently the value of ivory, to have prevented them from committing the tusks to the earth, lead to the belief that by far the greater number of these remains which have been dug up, have been deposited here, not by the hands of man, but by the changes which, at least, the surface of this globe has undergone, at very remote periods. The circumstances, indeed, under which many of these have been found, afford indubitable proof of this fact.

In France, where it is well known that living elephants have been much less frequent, at least in times of which we have any record, than either in Italy or in Greece, their fossil remains have been found in a great number of places, and in situations which prove their deposition at a very remote period. The whole valley through which the Rhine passes, yields fragments of this animal, and perhaps more numerously on the side of Germany than on that of France. Not only on its course, but in the alluvia of the several streams which empty themselves into it, are these fossil remains also found. Thus Holland abounds with them, and even the most elevated parts of the Batavian Republic are not exempt from them.

The whole of Germany and of Switzerland appear to particularly abound in these wonderful relics. The greater number which has been found in these parts is, perhaps, as is observed by M. Cuvier, not attributable to their greater abundance, but to the number of well-informed men, capable of making the necessary researches, and of reporting the interesting facts they discover.

As in the banks of the Rhine, so in those of the Danube, do these fossils abound. In the valley of Altmuhl is a grand deposit of these remains. The bones which have been found at Krembs, in Sweden; at Baden, near Vienna; in Moravia; in different parts of Hungary and of Transylvania; at the foot of the Hartz; in Hesse; at Hildersheim; all appear to be referable to this animal. So also are those which are found on the Elbe, the Oder, and the Vistula. Different parts of the British empire are not less productive of these remains.

In London, Brentford, Harwich, Norwich, Gloucestershire, Staffordshire, Warwickshire, Salisbury, the Isle of Sheppey, and indeed in several other parts of Great Britain, have different remains of these animals been found.

When we add to those places which have been already enumerated, Scandinavia, Ostrobothnia, Norway, Iceland, Russia, Siberia, Tunis, America, Huehuetoca, near Mexico; and Ibarra, in the province of Quito, near Peru; it will appear that there is hardly a part of the known world, whose subterranean productions are known to us, in which these animal remains have not been found.

M. Cuvier is satisfied, from actual comparison of several skulls of the East Indian and African elephants, that different specific characters exist in their respective skulls. In the Indian elephant, the top of the skull is raised in a kind of

double pyramid; but, in the African, it is nearly rounded. In the Indian the forehead is concave, and in the African it is rather convex. Several other differences exist, not necessary to be here particularized, which seem to be fully sufficient to mark a difference of species.

A cursory view is sufficient to enable us to determine that the ordinary fossil teeth of elephants are not of the African species; and it may be further said, that the greater number of these teeth bear a close resemblance to the East Indian species, showing, on their masticating surface, bands of an equal thickness through their whole length, and rudely crenulated. So great, indeed, is the resemblance, that Pallas, and most other writers, have considered the fossil elephant as being of the same species with the Asiatic.

M. Cuvier, anxious to discover the degree of accordance of the fossil elephant's skeleton with that of the living species, compared the fossil skull found in Siberia, by Messerschmidt, with those of the African and Asiatic elephants. The result of his comparison was, that in the fossil species the alveoli of the tusks are much longer; the zygomatic arch is of a different figure; the post-orbital apophysis of the frontal bone is longer, more pointed, and more crooked; and the tubercle of the os lachrymalis is considerably larger, and more projecting. To these peculiarities of the fossil skull, M. Cuvier thinks, may be added the parallelism of the molares.

Comparing together the bones of the Asiatic and of the African elephant, he was able to discover some differences between them, as well as between those and some of the fossil bones which he possessed. These latter he found, in general, approached nearest to those of the Asiatic elephant. He concludes with supposing, that the fossil remains are of a species differing more widely from the Asiatic elephant, than the horse does from the ass, and therefore does not think it impossible but that it might have existed in a climate which would have destroyed the elephant of India.

It may, therefore, be assumed as certain, from the observations of M. Cuvier, that at least one species of elephants has existed, of which none are now known living; and, should the difference of structure which has been pointed out, in some of the fossil teeth, be admitted as sufficient to designate a difference of species, it may be then said, that there exist the fossil remains of, at least, two species of elephants, which were different from those with which we are acquainted.

From the preceding observations it appears then, that the fossil elephantine remains, notwithstanding their resemblance in some respects to the bones of the Asiatic elephant, have belonged to one or more species, different from those which are now known. This circumstance agrees with the facts of the fossil remains of the tapirs and rhinoceroses, which appear to have differed materially from the living animals of the same genera. The remains of elephants obtained from Essex, Middlesex, Kent, and other parts of England, confirm the observations of Cuvier, that these remains are generally found in the looser and more superficial parts of the earth, and most frequently in the aluvia which fill the bottoms of the vallies, or which border the beds of rivers. They are generally found mingled with the other bones of quadrupeds of known genera, such as those of the rhinoceros, ox, horse, &c. and frequently also with the remains of marine animals.

We now come to the examination of the mastodon, one of the most stupendous animals known, either in a recent or a fossil state; and which, whether we contemplate its original mode of existence, or the period at which it lived, our minds cannot but be filled with astonishment.

The first traces of this animal are sketched in a letter from Dr. Mather, of Boston, to Dr. Woodward, in 1712, and are transcribed from a work in manuscript, entitled

Biblia Americana. In this work, teeth and bones of prodigious size, supposed to be human, are said to have been found in Albany, in New England. About the year 1740, numerous similar bones were found in Kentucky, on the Ohio, and dispersed among the European virtuosos.

Many bones of this animal having been found, in 1799, in the State of New York, in the vicinity of Newburgh, which is situated on the Hudson, or North River, Mr. C. W. Peale, of Philadelphia, purchased these, with the right of digging for the remainder.

The country in which these remains are found is like an immense plain, bounded on every side by immense mountains. On digging into the morasses where these bones are found, the following strata are generally met with: one or two feet of peat, one or two feet of yellow marl, with vegetable remains; about two feet of grey marl, like ashes, and, finally, a bed of shell marl. It is in the grey marl that the bones are chiefly found.

These remains are also found on this side of the three great chains of mountains, the Aleganys, the North Mountains, and the Blue Mountains; in the interior parts of Pennsylvania and Carolina; and in New Jersey, a few miles from Philadelphia.

From a careful attention to every circumstance, M. Cuvier conceives that we have a right to conclude, that this great mastodon, or animal of the Ohio, did not surpass the elephant in height, but was a little longer in proportion; its limbs rather thicker; and its belly smaller. It seems to have very much resembled the elephant in its tusks, and indeed in the whole of its osteology; and it also appears to have had a trunk. But, notwithstanding its resemblance to the elephant, in so many particulars, the form and structure of the grinders are sufficiently different from those of the elephant, to demand its being placed in a distinct genus. From the later discoveries respecting this animal, he is also inclined to suppose that its food must have been similar to that of the hippopotamus and the boar, but preferring the roots and fleshy parts of vegetables; in the search of which species of food it would, of course, be led to such soft and marshy spots as he appears to have inhabited. It does not, however, appear to have been at all formed for swimming, or for living much in the waters, like the hippopotamus, but rather seems to have been entirely a terrestrial animal.

There appear to be three living species of *rhinoceros*: 1. That of India, a unicorn, with a rugose coat, and with incisors, separated, by a space, from the grinders. 2. That of the Cape, a bicorn, the skin without rugæ, and having twenty-eight grinders, and no incisors. 3. That of Sumatra, a bicorn, the skin but slightly rugose, thus far resembling that of the Cape, but having incisive teeth like that of India.

The fossil remains of the rhinoceros have been generally found in the same countries where the remains of elephants have been found; but they do not appear to have so generally excited attention; and perhaps but few of those who discovered them were able to determine to what animal they belonged. Thus a tooth of this animal is described by Grew merely as the tooth of a terrestrial animal; and the remains of this animal, found in the neighbourhood of Canterbury, were supposed to have belonged to the hippopotamus.

In Hartzberg, in the principality of Grubenhagen, Quedlimburg, Darmstadt, the borders of the Rhine, Mentz, Strasbourg, the neighbourhood of Cologne, Westphalia, numerous parts of France, and in several parts of Great Britain, have the remains of the rhinoceros been found. In Siberia these remains have been found in considerable quantities. Pallas, whose researches have been particularly directed to this part of the world, made the astonishing discovery of a complete rhinoceros, still covered by its skin, and buried in the sand on the borders of the river Wiluji.

In Germany and Hungary are caverns containing fossil bones. Among the most remarkable of these, are those of Gaylenreuth, on the confines of Bayreuth. The opening to these, which is about seven feet and a half high, is at the foot of a rock of limestone of considerable magnitude, and in its eastern side. Immediately beyond the opening is a magnificent grotto, of about three hundred feet in circumference, which has been naturally divided by the form of the roof into four caves. The first is about twenty-five feet long and wide, and varies in height from nine to eighteen feet, the roof being formed into irregular arches. Beyond this is the second cave, about twenty-eight feet long and of nearly the same width and height with the former.

A low and very rugged passage, the roof of which is formed of projecting pieces of rocks, leads to the third grotto; the opening into which is a hole three feet high and four feet wide. This grotto is more regular in its form, and is about thirty feet in diameter, and nearly round: its height is from five to six feet. This grotto is very richly and fantastically adorned by the varying forms of its stalactitic hangings. The floor is also covered with a wet and slippery glazing, in which several teeth and jaws appear to have been fixed.

From this grotto commences the descent to the inferior caverns. Within only about five or six feet an opening in the floor is seen, which is partly vaulted over by a projecting piece of rock. The descent is about twenty feet; and occasioned to M. Esper and his companions some little fear lest they should never return, but remain to augment the zoolithes contained in these terrific mansions. This cavern was found to be about thirty feet in height, about fifteen feet in width, and nearly circular; the sides, roof, and floor, displaying the remains of animals. The rock itself is thickly beset with teeth and bones, and the floor is covered with a loose earth, the evident result of animal decomposition, and in which numerous bones are imbedded.

A gradual descent leads to another grotto, which, with its passage, is forty feet in length, and twenty feet in height. Its sides and top are beautifully adorned with stalactites. Nearly twenty feet further is a frightful gulf, the opening of which is about fifteen feet in diameter; and, upon descending about twenty feet, another grotto, about the same diameter with the former, but forty feet in height, is seen. Here the bones are dispersed about; and the floor, which is formed of animal earth, has great numbers of them imbedded in it. The bones which are here found seem to be of different animals; but in this, as well as in the former caverns, perfect and unbroken bones are very seldom found. Sometimes a tooth is seen projecting from the solid rock, through the stalactitic covering, showing that many of these wonderful remains may here be concealed. A specimen of this kind, which I possess, from Gaylenreuth, is rendered particularly interesting, by the first molar tooth of the lower jaw, with its enamel quite perfect, rising through the stalactitic mass which invests the bone. In this cavern the stalactites begin to be of a larger size, and of a more columnar form.

Passing on, through a small opening in the rock, a small cave, seven feet long and five feet high, is discovered; another small opening, out of which leads to another small cave; from which a sloping descent leads to a cave twenty-five feet in height, and about half as much in its diameter, in which is a truncated columnar stalactite, eight feet in circumference.

A narrow and most difficult passage, twenty feet in length, leads from this cavern to another, five and twenty feet in height, which is every where beset with teeth, bones, and stalactitic projections. This cavern is suddenly contracted, so as to form a vestibule six feet wide, ten long, and nine high, terminating in an opening close to the floor, only three feet wide and two high, through which it is necessary to writhe with the body on the ground. This leads

into a small cave, eight feet high and wide, which is the passage into a grotto twenty-eight feet high, and about three and forty feet long and wide. Here the prodigious quantity of animal earth, the vast number of teeth, jaws, and other bones, and the heavy grouping of the stalactites, produced so dismal an appearance, as to lead Esper to speak of it as a perfect model for a temple for a god of the dead. Here hundreds of cart-loads of bony remains might be removed, pockets might be filled with fossil teeth, and animal earth was found to reach to the utmost depth to which they dug. A piece of stalactite, being here broken down, was found to contain pieces of bones within it, the remnants of which were left imbedded in the rock.

From this principal cave is a very narrow passage, terminating in the last cave, which is about six feet in width, fifteen in height, and the same in length. In this cave were no animal remains, and the floor was the naked rock.

Thus far only could these natural sepulchres be traced; but there is every reason to suppose that these animal remains were disposed through a greater part of this rock.

Whence could this immense quantity of the remains of carnivorous animals have been collected, is a question which naturally arises, but the difficulty of answering it appears to be almost insurmountable. The theory of Sir Richard Phillips appears to furnish a clue to the cause of these accumulations. He supposes that while the perihelium point progresses southward, the sea gradually retires from the land, and that tides meeting at certain points of land, or washing round such points, would there accumulate enormous quantities of bones and other substances, susceptible of being transported by water; and in confirmation of this idea, he appeals to similar circumstances which present themselves on the shores of every sea.

Mr. William Smith, long since, pointed out the necessity of ascertaining the fossils belonging to each particular stratum, and collected for the information of others, specimens of numerous strata, with some of their peculiar fossils.

With the wish of showing how beneficial inquiries may prove when thus connected, we will endeavour to ascertain the proper strata of some of the fossils.

According to the actual observations of Mr. Smith, as given by Mr. Farey, in his General View of the Agriculture and Minerals of Derbyshire, vol. i. p. 111, the following are the upper strata which have been discovered in this island, disposed in the order in which they occur.

1. Sand.
2. Clay, with septaria.
3. Sand, with shells, varying in thickness and in mixture with other substances.
4. Soft chalk with flinty nodules.
5. Hard chalk.
6. Chalk marl.
7. Aylesbury limestone.
8. Sand and clay strata, in one of which is a dark-coloured shelly limestone, called Sussex marble.
9. Woburn sand, in which is a stratum of fullers earth.
10. A thick clay, called the clunch clay.
11. Bedford limestone.
12. A thick clay.
13. Ragstone of Barnack, &c.
14. Limestone and grey slate of Stunsfield, Colley Water, &c.
15. Sand.
16. Bath free-stone.
17. Sand and clays.
18. Maidwell limestone.
19. Lias clay, containing the blue and white Lias limestone.
20. Sand.
21. Red marl.

Beneath these follow the gritstones and coal shales, and the alternating limestones and toadstones. Parts of these inferior strata appear to have been so raised and so denudated of their superincumbent strata, by some astonishing power, in Derbyshire, Staffordshire, and other adjacent counties, as to give the opportunity of examining the out-crop, or appearance on the surface, of these strata, which were originally covered by all the strata which have been enumerated above. The last discovered, entrochal limestone

of Derbyshire, must have originally lain, according to Mr. Farey's calculation, three miles perpendicularly lower than the upper part of the chalk strata.

The entrochal limestone of Derbyshire, &c. have their antiquity manifested by their original deep situation, and by the peculiar fossils which they contain.

Above these strata are those of the alternating coal shales and gritstones, and on these is disposed a stratum of red marl. Over this is a stratum of sand; but neither in this nor the preceding stratum does it appear that any fossils have been noticed.

The lias clay is the next superior stratum, and contains beds of limestone, called the blue and the white lias limestone.

The fossils of this stratum are exceedingly numerous, and some of them are again seen in some of the superior strata; but the characters of the greater part are such as to point them out decidedly as peculiar to this stratum.

In this stratum the fossil shells are exceedingly numerous: particularly *ammonitæ*, *nautilitæ*, *terebratulitæ*, *gryphitæ*, *mytulitæ*, *modiolitæ*, *spondylitæ*, *trigonitæ*, *belemnitæ*, and the large *donaxformed bivalve*. In this stratum are also found fish of an unknown genus, with large square scales, and several species of *testudo*, *lacerta*, &c.

Immediately above this stratum is a blue marl-stone, called the Maidwell limestone, with the fossils of which we are unacquainted. Nor are we able to speak with more information of a great number and thickness of sands and clays which lie over the Maidwell limestone.

To these succeed the Bath freestone strata, which may be traced in their range through the island. The upper part is a white or light grey limestone; beneath which is the oolite, or roe-stone, and under this a considerable thickness of very light-coloured free-stone, then sand and clays, and a free-stone of various hues of yellow and red.

The fossils of this strata are chiefly bivalve shells, of which generally only the casts or the impressions remain.

Above these is a sand stratum, and in this is the limestone and grey slate strata of Stansfield, Colley Weston, Chippenham, &c. In this stratum, the *discoidal echinitæ* abound, as well as the *trigonitæ*, and *belemnitæ*. In this strata are also found *pinnitæ*, *crenatulitæ*, and the *flat fossil oyster*. But the fossils which are here most abundant are the *bufonitæ*, and other part of the palates and the teeth of fishes.

On these strata lies the rag-stone, which has been employed for most of the ancient well-preserved buildings in the eastern part of the island. This stone is formed of small bivalves, chiefly *ammonitæ*.

Above this is a thick clay, on which is the limestone called the Bedford limestone; in which are found small *gryphitæ*, *belemnitæ*, *ostreitæ*, *pectinitæ*, minute *crenatulitæ*, *pinnitæ*, a few *trigonitæ*, the uncommonly marked bivalve, and various other shells.

Immediately over this is a stratum of clay called clunch clay, from the beds of clunch, a soft chalk like stone, which is found towards the top of it. *Ammonitæ*, large *gryphitæ*, *belemnitæ*, and various bivalves, are found in this stratum.

Above this is the Woburn sand, containing in its lower parts fragments of silicified wood. To this succeed several sand strata and clays, and in one of these a thin bed of the shelly limestone, called Sussex marble. Above this is the Aylesbury limestone containing large *ammonitæ*, *gryphitæ*, &c.

Over this is disposed the chalk marl. The lower or hard chalk rests on the chalk marl, and acquires in different parts different degrees of hardness, forming in some places a white free-stone, and in others a softer freestone. This stratum affords striking instances of the fact, first noticed by Mr. Smith, of certain organic remains being peculiar to, and only found lodged in, particular strata. The chief fossils which are found in this stratum are *ammonitæ* of a tolerably large size; and a smaller species of an oval form, different from those found in any other strata.

Immediately on this stratum is placed that of the soft chalk, containing silex in the state of sand with interposed layers, and large, interspersed, and irregular nodules of black flint. The fossils of this stratum differ in a very remarkable degree from those of all the inferior strata.

On this chalk is deposited a thick stratum of white sand, over which is a sand of a darker colour, and above this various thin strata, or patches, of marl, shells, sandstone, coarse limestone, fragments of shells, pebbles, &c.

Cuvier draws the following deductions: That these different bones are buried almost every where, in nearly similar beds: they are often blended with some other animals resembling those of the present day.

That these beds are generally loose, either sandy or marly; and always neighbouring, more or less, to the surface.

That it is therefore probable, that these bones have been enveloped by the last, or by one of the last, catastrophes of this globe.

That in a great number of places they are accompanied by the accumulated remains of marine animals; but in some places, which are less numerous, there are none of these remains: sometimes the sand or marl, which covers them, contains only fresh water shells.

That no well-authenticated account proves that they have been covered by regular beds of stone, fille with sea shells; and, consequently, that the sea has remained on them, undisturbed, for a long period.

That the catastrophe which covered them was, therefore, a great, but transient, inundation of the sea.

That this inundation did not rise above the high mountains; for we find no analogous deposits covering the bones, nor are the bones themselves there met with, not even in the high valleys, unless in some of the warmer parts of America.

That these bones are neither rolled nor joined in a skeleton, but scattered, and in part fractured. They have not then been brought from afar by inundation, but found by it in places where it has covered them, as might be expected, if the animals to which they belonged had dwelt in these places, and had there successively died.

That before this catastrophe, these animals lived, therefore, in the climates in which we now dig up their bones: it was this catastrophe which destroyed them there; and, as we no longer find them, it is evident that it has annihilated those species. The northern parts of the globe, therefore, nourished formerly species belonging to the genus elephant, hippopotamus, rhinoceros, and tapir, as well as to mastodon, genera of which the four first have no longer any species existing, except in the torrid zone; and, of the last, none in any part.

In 1821, an assemblage of fossil teeth and bones, of elephant, rhinoceros, hippopotamus, bear, tiger, hyæna, and sixteen other animals, were discovered in a cave at Kirkdale, in Yorkshire. These have been severally described and illustrated by Professor Buckland, in the Philosophical Transactions; and the discovery may be regarded as one of the most interesting of modern times.

It seems evident from the plain language of nature and observation, that the sea has more than once overflowed the land at periods very distant, and to account for these successive floods, Sir Richard Phillips has published an explanation, growing out of his theory of matter and motion. He ascribes the elliptical orbit of the earth to its own varied reaction, and this variation he ascribes to the varied action of the waters in the northern and southern hemispheres. When the action is greatest, the lever or distance is shortened, as when the sun passing through the southern signs, and is vertical over the great masses of waters in the southern hemisphere; and *vice versa*, the distance or lever is lengthened, as the sun passes vertical over the narrower seas, under the northern tropic. The waters however, by increased action, enlarge their own beds, hence the pointed form of S. Africa and America, and hence they will progressively ascend into the

northern hemisphere, and carry the perihelium points from Capricorn, where it now is to Cancer. This period is known by observation to be 10,450 years, and it was last in Cancer 10,450 years ago. When the waters of the northern hemisphere were equal to those now in the southern; and all the northern continents were covered with sea for several thousand years, while the perihelium point was moving through the northern signs. Hence the perihelion began to pass south, about 6000 years ago, and the dry land began to appear in these northern parellels, the ocean enlarging its bed to the southward; and every 20,900 years, the same phenomena return. Such is Sir R. Phillips's theory of the recurring sub-mersions of the land, and the discovery of tropical remains, without the latitude of the present tropics, he ascribes to the increased parallelism of the earth's rotation with the plane of its orbit, the measure of which is determined, and he conceives the axis of the earth may once have been far more inclined than at present; a circumstance which would render the change of the perihelium still more operative, and would change the climates of every parellel.

There does not appear, says M. Brocchi, to be any essential or constant difference of species in the fossil shells found in the Sub-Apennine Hills, either in regard to the greater or less depth of the strata in which they are found, or the materials of which the strata are composed. They are not scattered confusedly through the different beds, but often appear to be distributed in families and distinct species: that distribution, however, has no correspondence with the situation of the beds. Not only the shells which are found in the present sea, but those of which the prototypes are unknown, the indigenous, as well as the exotic, are found both in the marl and in the sand that lies over it. There are perhaps some exceptions, some shells which belong more particularly to the sand; but they are not such as to warrant any general deduction. All the tertiary deposits do not contain shells, there being extensive tracts where they are either wholly wanting, or are only to be traced by some scattered vestiges, although the materials composing those districts are the same as those beds which contain the fossil shells in greatest abundance.

There is, in general, a great analogy between the fossil shells found in different parts of Italy. The same species are found in Piedmont, in the territories of Placentia and Bologna, in Romagna, Tuscany and Puglia, and even in Calabria, as is shown by the work of Scilla. It is also remarkable, that some particular shells, the originals of which are unknown, are common in several places far distant from each other.

The fossil shells of the Sub-Apennines may be divided into two general classes, the one comprehending the shells that are still found in the sea, the other comprehending those whose prototypes are unknown. The first of these classes may be farther subdivided, by distinguishing the species found in the Adriatic and Mediterranean from those which belong to distant seas. The number of the indigenous shells is very considerable; and there are many examples of those which have been described by naturalists as peculiar to the Asiatic, African and American seas. Among the most remarkable of these, are the *bulla ficus* of the Indian and American ocean, the *buccinum plicatum* of Jamaica, the *turbo imbricatus* of the Atlantic, the *murex ramosus* of the Red sea and Persian gulph, and the *murex senensis* of the coasts of Africa.

That there are innumerable instances of the existence of fossil organized bodies in such situations as incontestably prove that the surface of the earth has undergone the most extraordinary changes, every geologist admits; but M. Brocchi shows, that some geologists have been rather hasty in their conclusions with respect to many of those fossil shells which were said to belong to climates far distant from that where they are found.

We learn from the work of Olivi, that many of the shells which were considered as belonging exclusively to the Asiatic and American seas, are found in the Adriatic; and Renieri has discovered twice as many species as were known to his predecessor.

In the catalogue which Lamark has given of the fossil shells that have been found in the neighbourhood of Paris, there are about five hundred species; and it is wonderful how few of them resemble those found in the Sub-Apennine Hills, and how many genera there are among them, wholly unknown in Italy. But the most remarkable difference in the fossil shells of the two countries, is in those of which the prototypes are unknown. These greatly predominate in France, and, with a few exceptions, are wholly different from those which exist in Italy. In the latter country, many species are wanting which are common in the neighbourhood of Paris; and many occur in Italy that have not been found there. There are, moreover, many shells of constant occurrence in the marl, and which are now common in the Adriatic and Mediterranean seas, that do not appear to have been met with by Lamark.

Besides these vast collections of fossil shells, the remains of many other tribes of marine animals, are found in the Sub-Apennine Hills. The most remarkable of these are the remains of great whales, not only in separate bones, but in entire skeletons. They have been found in various parts of Tuscany, in the territory of Bologna, in Piedmont, and in the neighbourhood of Feltre, a country situated about 1200 feet above the level of the sea. Near Castell' Arquato in the territory of Placentia, a skeleton was found nearly entire, measuring 21 feet in length. All the bones were in their natural situation, and had undergone no other change than the loss of the animal gluten. Besides this skeleton, there were found a part of one still larger, and many detached vertebræ, ribs and jaw-bones of the same animal. There was also found in the same neighbourhood, the skeleton of a dolphin six feet long, a part of another skeleton belonging to an animal of the same tribe, and the jaw-bone of a dolphin quite petrified, containing the greater part of the teeth, with their natural enamel preserved.

All these animal remains, and others of the same sort, which have been dug up in various parts of Italy, are found in the blue marl. Some of the bones found in the territory of Placentia, and the portion of the whale's jaw-bone found in Valdarno Inferiore, which is in the Museum of Florence, are encrusted with oyster-shells, which must have lived and grown upon them. So that it is quite evident, as M. Brocchi remarks, that these skeletons must have remained as such, for a considerable time at the bottom of the sea, and that they cannot be considered as the remains of animals carried by some sudden inundation to the places where they were dug up.

However striking the occurrence of those bones, in such situations, may be, it is still more extraordinary to find, in the same places, the remains of those great land animals that now inhabit the torrid zone.

Among all the phenomena of *geology*, there is none more wonderful than this, or one more worthy of deep reflection; nor is there any fact which is more puzzling to the ingenuity of naturalists, who bewilder themselves in a labyrinth of conjecture, how the elephant, rhinoceros, and the hippopotamus, should be found buried in our climates. The multitude of these skeletons renders the fact still more surprising. Targioni calculates the number of elephants' bones that had been dug up in Valdarno Superiore in his time, equal to those of twenty individuals; and this number has been so much augmented by subsequent discoveries, that the district may be considered as a vast cemetery of these gigantic animals. It was ascertained that, before the peasants of the neighbourhood thought of preserving these bones for the sake of selling them to the curious, some of them had been in the habit

of surrounding their gardens with palisades of the tibiæ and thigh bones of the elephant. One of the persons who are in the habit of searching for these bones, ascended the hill of Poggio Rosso, where, after having removed the earth in four or five places, he found a large elephant's tusk: from thence he went to the Colle degli Stecconi, and with the same facility he dug up a large grinder, with some of the bones of the cranium, and two tusks—one of which was nearly five feet long, and eight inches in its greatest diameter. In Valdarno Superiore, they also find bones of the rhinoceros, the hippopotamus, stag's horns, jaw-bones and teeth of the mastodonton, and other herbivorous animals, which seem to belong to the horse and the ox. The district where these remains are found in the greatest abundance, is that on the right bank of the Arno, between Figline, Castelfranco, and San Giovanni, and from Rinaccio to Montanino; from whence were obtained the chief part of those that are in the Royal Museum of Florence, in that of Professor Targioni, and those belonging to the Accademia Valdarnese di Figline, who are in possession of a very fine series, collected chiefly by the Padre Molinari, a monk of Vallombrose.

These remains are not confined to Valdarno nor to Tuscany, but are found in different places on both sides of the Apennines, from Lombardy to Calabria. M. Brocchi gives a list of the most remarkable places where they have been found, distinguishing the different species of animals. He enumerates forty-six specimens of the bones of elephants, found in different situations—in Piedmont near Verona—in the territories of Pavia, Tortona, Placentia and Bologna—in Puglia, Basilicata, and Calabria—in the neighbourhood of Pozzuoli near Naples—twelve different places near Rome—near Viterbo, Todi, Perugia and Cortona—in Valdarno Superiore and Inferiore, near Leghorn—and also at Palermo in Sicily, which last country appears to abound in fossil bones. On one occasion, there was found in the neighbourhood of Rome, the entire skeleton of an elephant; but it was unfortunately destroyed by the workmen. He describes fifteen specimens of the mastodonton found in different parts of Piedmont and Lombardy, and on both sides of the Apennines, but not farther south than Perugia. At Castell' Arquato, there was found the greater part of the skeleton of a rhinoceros; and in Valdarno Superiore, and the territory of Perugia, different bones of the same animal. In Valdarno Superiore, in Piedmont, and in the neighbourhood of Verona, remains of the hippopotamus have been dug up; and many specimens of the head and horns of the urus have been found in the territories of Verona, Pavia, Siena, in the Marca di Ancona, and near Rome. A head of the Irish elk was found in Oltrepo Pavese, another in the vicinity of Voghera, and a third near Lodi Vecchio on the banks of the Lambro.

The bones of all these animals are found, in general, a few feet below the surface; and the soil in which they are buried is commonly a yellow sand, generally calcareous, but sometimes almost wholly siliceous. Of this last description is the soil in many parts of Valdarno Superiore, which does not effervesce with acids, and is composed of grains of quartz and scales of mica, mixed with a reddish yellow oxide of iron. When it is not agglutinated, it is called *sansino* by the inhabitants; and when, as is often the case, it is consolidated, they call it *tufo*. The elephant's tusk found by Canali near Perugia, was in a field covered with rounded pebbles; and that mentioned by Baccio as having been dug up near Rome in his time (1580), appears to have been discovered in the midst of coarse gravel. These fossil remains of land animals are not confined to the sand and gravel alone, but are also sometimes found in the blue marl when it occupies the surface, and is not covered by other deposits. There are instances of this in Valdarno itself, on the Colle degli Stecconi, where a part of the head of an ele-

phant and other remains were dug out. The tusk of Belvedere, near Jesi, was in a soil of the same sort, as well as the jawbone of the rhinoceros found by Canali in the territory of Perugia. One of the vertebræ of the skeleton of the rhinoceros found at Castell' Arquato was in the marl, while all the other bones were in the siliceo-calcareous sand lying over it.

It is a very curious circumstance, and one of considerable importance in the physical history of the country round Rome, that bones of the elephant have been found there, imbedded at the depth of twenty feet, in the volcanic tufo.

Fortis, in his *Memoires sur L' Hist. Nat.* has said, that the tusk of an elephant was hewn out of a bed of stone of ancient formation, containing exotic marine remains, found near Leghorn. From this description one might suppose, that it was a solid limestone, similar to that of the Apennines; but M. Brocchi informs us, that this stone is a calcareous tufo, of a cellular texture, having grains of sand of different sizes imbedded in it; and the shells it contains are so broken, that it is impossible to say to what species they belong. There is a considerable bed of it, which is partly washed by the waves of the sea; and it is gradually increasing in extent, by the agglutination of the grains of sand by a calcareous cement. This is evidently a rock, which has been formed in the same manner as that on the shore of Guadaloupe, in which the human skeleton was found; but from M. Brocchi's account of the rock near Leghorn, that of Guadaloupe is of a much more consolidated texture.

We have already mentioned, that some of the whale's bones found in the territory of Placentia, and in Valdarno, were encrusted with oyster-shells; but it is still more remarkable, that some of the elephant's bones dug up in Valdarno, and in the territory of Placentia, have also been found covered with the same shells, and adhering to them so firmly, that they could not be detached without breaking the bone. All the more prominent parts of these bones, such as must have been broken had they been brought to their present situations from a distance, are in the highest state of preservation; nor have any bones been found having the slightest appearance of having been worn by attrition.

Among all the fossil bones that have been found in different parts of Italy, there are very few which can, with any degree of certainty, be referred to carnivorous land animals. In the museum of Florence, there is a portion of a jawbone with three teeth, which appears to have belonged to an animal of this class; and there are some bones and teeth, in the collections of Targioni and Tartini, which Cuvier considered as belonging to the bear. All these were found in Valdarno. We have also in this work a farther confirmation of the extraordinary fact, perhaps the most important that has yet been established by the researches of the geologist, that in all the collections of fossil bones that have been discovered in various parts of the world, even amongst the gravel scattered on the surface during the last of the innumerable changes which the crust of the earth has undergone, not a trace of the existence of man has been discovered.

FRANKINCENSE is the product of the juniperus lycia. See OLIBANUM.

FREEZING. The act of a liquid becoming solid from the abstraction of caloric.

FRENCH BERRIES. The fruit of the rhamnus infectorius, called by the French *graines d'Avignon*. They give a pretty good yellow colour, but void of permanency. When used for dying, the cloth is prepared in the same manner as for weld.

FRIESLAND GREEN. Ammoniaco-muriate of copper, the same with Brunswick green.

FRITT. The materials of glass are first mixed together, and then exposed to calcination by a degree of heat not sufficient to melt them. The mass is then called fritt.

FRUITS OF VEGETABLES.

Fruits in the organization of their soft parts, approach to the nature of bulbs. They contain much nourishment laid up in their cells, for the use of the embryo plant. Mucilage, sugar, and starch, are often found combined with vegetable acids. Hence they are both palatable and nutritive.

The value of fruits for fermentation, may be judged of from the specific gravity of their expressed juices. The best cider and perry are made from those apples and pears that afford the densest juices; and a comparison between fruits may be made with tolerable accuracy, by plunging them together into a saturated solution of salt, or a strong solution of sugar; those that sink deepest will afford the richest juice.

FULIGINOUS. Vapours which possess the property of smoke; namely, opacity, and the disposition to apply themselves to surrounding bodies in the form of a dark coloured powder.

FULLERS EARTH is of important use in the manufacture of woollen cloth, from its possessing the property of absorbing grease; by which means, when the cloth is washed, it is freed from the grease, which was necessary to prevent it from being too much worn by friction in the manufacture. The best is found in Buckinghamshire and Surrey. When good, it has a greenish, white, or grey colour, falls into powder in water, and communicates to it a milky hue, and deposits very little sand, if mixed with hot water. It appears to melt on the tongue like butter. It is greasy to the touch. Its constituents are 53 silica, 10 alumina, 1.25 magnesia, 0.50 lime, 0.10 muriate of soda, 9.75 oxide of iron, and 24 water, Bergman found 24 alumina.

FULMINATING AND FULMINATION. In a variety of chemical combinations, it happens, that one or more of the principles assume the elastic state with such rapidity, that the stroke against the displaced air produces a loud noise. This is called fulmination, or much more commonly detonation.

The most remarkable instances of expansion by heat with which we are acquainted, are those where explosive mixtures are used, and where reverberation of the air is the consequence. In the explosion of these compounds (which are of various kinds), the simple substances of which they are composed are either resolved into their primary states, or they immediately enter into combinination with other substances, which, like themselves, have just been liberated. In most cases, they not only assume, but retain the elastic form. The explosion of these bodies is doubtless owing to their combination with heat: but whether the heat has been latent in themselves, or whether they are capacitated, by a slight elevation of temperature, suddenly to rob the surrounding atmosphere of its heat, is not known.

It is remarkable that nitrogen is a component part of most explosive mixtures. Explosion, or the reverberation of air, is merely a consequence of their sudden expansion, or assumption of the elastic form.

The general causes of explosion in the following experiments, are heat, inflammation, friction or percussion, and mixture.

Fulminating gold, and fulminating powder, are the most common substances of this kind, except gunpowder. For the latter of these, see the article GUNPOWDER. The fulminating powder is made by triturating in a warm mortar, three parts, by weight, of nitre, two of carbonate of potash, and one of flowers of sulphur. Its effects, when fused in a ladle, and then set on fire, are very great.

If a solution of gold be precipitated by ammonia, the product will be fulminating gold. Less than a grain of this, held over the flame of a candle, explodes with a very sharp and loud noise. This precipitate, separated by filtration, and washed, must be dried without heat, as it is liable to explode with no great increase of temperature; and it must not be put into a bottle closed with a glass stopple, as the friction of this would expose the operator to the same danger.

Fulminating silver may be made by precipitating a solution of nitrate of silver by lime water, drying the precipitate by exposure to the air in two or three days, and pouring on it liquid ammonia. When it is thus converted into a black powder the liquid must be poured off, and the powder left to dry in the air. It detonates with the gentlest heat, or even with the slightest friction, so that it must not be removed from the vessel in which it is made. If a drop of water fall upon it, the percussion will cause it to explode. It was discovered by Berthollet.

Brugnatelli made a fulminating silver by powdering a hundred grains of nitrate of silver, putting the powder into a beer glass, and pouring on it first an ounce of alcohol, then as much concentrated nitrous acid.

The mixture grows hot and boils, and an ether is formed which is changed into gas. By degrees the liquor becomes milky and opaque, and is filled with small white clouds. When all the grey powder has taken this form, distilled water must be added immediately to stop the ebullition, and to prevent the matter from being redissolved and becoming a mere solution of silver. The white precipitate is then to be collected on a filter and dried. The force of this powder is very great, far exceeding fulminating mercury. A single grain placed on a lighted coal makes a deafening report. The same will happen if the electric spark be made to pass through it.

To form fulminating mercury, a hundred grains are to be dissolved with heat in an ounce and a half, by measure, of nitric acid. When the solution is cold, it is to be poured on two ounce measure of alcohol, and heat applied till an effervescence takes place. When a precipitate is thrown down, it must be collected in a filter, washed, and dried by a gentle heat. It detonates with little heat or friction.

Detonating silver explodes by contact with nitric acid. Throw 2 grains of detonating silver into a gallipot, containing 1 drachm of nitric acid; explosion and inflammation will take place, and the acid will be thrown about.

Fulminating copper is thus made:—Dissolve some pure copper in diluted nitric acid, and pour into it some liquid ammonia as long as a precipitate falls down. Pour the solution into an evaporating dish, and expose it to a temperature of 200° until the precipitate is merely in a moist state. Now place the dish in a lower temperature, until the powder is quite dry. This powder is known by the name of fulminating copper. Preserve it in a wide-mouthed phial, loosely covered with paper.

It may be made to explode by friction:—Put a grain of fulminating copper, on a hearth-stone, and rub it with the end of a poker; a loud explosion will be the consequence.

It also explodes when heated:—Put 2 grains of fulminating copper on a clean fire-shovel, and hold it over the fire; in a few seconds it will explode with great violence.

The following is the mode to prepare fulminating platinum:—Prepare a solution of nitro-muriate of platinum, and pour into it liquid ammonia, as long as a precipitate falls down. Filter the liquid, and pour water over the powder on the filter in order to wash it. Put this powder into a small vessel, with a solution of pure potass; and give it a boiling heat, until all the water has evaporated. Pour several waters over the residuum in order to wash it well; when the fluid that comes off is tasteless, put the remaining powder on paper, and dry it up by a heat not exceeding 200°. The fulminating platinum thus obtained is of a brownish colour. Too much should not be prepared at one time; and it should be preserved in the same way as the fulminating gold.

Three parts of chlorate of potass, and one of sulphur, triturated in a metal mortar, cause numerous successive detonations. A few grains placed on an anvil, and struck by a hammer, explode with great violence, and torrents of purple light appear round it. If thrown into concentrated sulphuric

acid, it takes fire, and burns with white flame, but without noise.

Six parts of chlorate, one of sulphur, and one of charcoal, detonate by the same means.

The detonations are much louder when the mixtures are wrapped up in double paper.

A fulminating powder, which will be quite harmless if the smallest precaution be used, may easily be made from sulphur, subcarbonate of potash and saltpetre. In the proportions of 1 of the first, 2 of the second, and 3 of the third. Let them be intimately mixed together, place a shovel on the fire, and lay half a tea-spoonful on it, and in a little while the mixture will become brown, and will explode with great violence and noise. If the shovel be examined, it will be found to be a little bent by the force of the powder. If a cup be placed over the powder on the shovel, it will be blown to pieces. The operator must in this case be cautious, and if merely the powder be used, he must not come near to hold his head over, lest part be blown in his face.

FUMING LIQUOR. To prepare the fuming liquor of Boyle, mix three parts of lime fallen to powder in the air, one of muriate of ammonia, and one of flowers of sulphur in a mortar, and distil with a gentle heat. The yellow liquor which first comes over, emits fœtid fumes. It is followed by a deeper coloured fluid which is not fuming. Boyle's fuming liquor is a hidroguretted sulphuret of ammonia.

The fuming liquor of Libarius is made by amalgamating tin with half its weight of mercury, triturating this amalgam with an equal weight of corrosive muriate of mercury, and distilling by a gentle heat. A colourless fluid at first passes over, and after this a thick vapour is thrown out at one single jet, with a sort of explosion, which condenses into a transparent liquor that emits copious, white heavy acrid fumes, on exposure to the air. In a closely stopped bottle no fumes are perceptible, but crystals form against the top of the bottle, as frequently to close the aperture.

Cadet's fuming liquor is obtained by distilling equal parts of acetate of potash, and arsenious acid, and receiving the product into glass vessels, kept cool by ice and salt. The liquor produced, emits a very dense, heavy, fœtid, noxious vapour, and inflames spontaneously in the air.

FUNGATES, the salts formed by the fungic acid and salifiable bases.

FUNGIC ACID is obtained from the boletus juglandis, and other fungi. They must be boiled to coagulate the albumen, then filtered, evaporated to the consistence of an extract, and acted on by pure alcohol. It is colourless, uncrystallizable, and of a very sour taste. It precipitates from the acetate of lead a white flocculent fungate, which is soluble in distilled vinegar.

FUNGIN. This seems to be a modification of the woody fibre. It is the fleshy part of mushrooms deprived of every thing soluble, by alcohol and water.

FUSIBILITY. The property by which bodies assume the fluid state. It depends upon the temperature, and some chemists consider it a solution of bodies in caloric, but this theory involves many disputed points.

An alloy of two or more metals is usually much more fusible than the metals taken separately.

FUSION. The act of fusion. Also the state of a fused body.

FUSTET. The wood of the rhus cotinus, or Venus's sumach, which yields a fine orange colour, but not at all durable.

FUSTIC, OR YELLOW WOOD. This wood, the morus tinctoria, is a native of the West Indies. It affords much colouring matter, which is very permanent. The yellow given by fustic without any mordant is dull, and browmish, but stands well. The mordants which are employed with weld, act on it in a similar manner, and by their means the colour is rendered more bright and fixed. As it abounds more with colouring matter than weld, a less quantity will suffice. The yellow of fustic inclines more to orange than that of weld.

G.

GABBRONIT. Scapolite.

GADOLINITE, is a mineral of a black colour, of various shades. It consists of 25·8 silica, 45 yttria, 16.69 oxide of cerium, 10·26 oxide of iron, and 0·60 volatile matter. It is found in Sweden.

GAHNITE, automalite, or octohedral corundum.

GALBANUM, exudes from the bubon galbanum. This juice comes over in masses, composed of white, yellowish, brownish yellow, and brown tears, unctuous to the touch, softening betwixt the fingers; of a bitterish, somewhat acrid, disagreeable taste, and a very strong smell; generally full of bits of stalks, leaves, seeds, and other foreign matters. Galbanum contains more of a resinous than gummy matter; one pound yields with alcohol upward of nine ounces and a half of resinous extract; but the gummy extract obtained by water from the same quantity, amounts only to about three ounces. The resin is hard, brittle, insipid, and inodorous; the gummy extract has somewhat of a nauseous relish, but could not be distinguished to be a preparation of galbanum. The whole smell, flavour, and specific taste of this juice, reside in an essential oil, which arises in distillation both with water and spirit, and gives a strong impregnation to both. From a pound of galbanum are obtained, by distillation with water, six drachms of actual oil, besides what is retained by the water. In this respect galbanum agrees with asafœtida, and differs from ammoniacum.

GALENA. The black ore of lead.

GALL of animals.—See *Bile*.

GALL-STONES. Calculous concretions are not unfrequently formed in the gall-bladder, and sometimes occasion great pain in their passage through the ducts into the duodenum, before they are evacuated. Of these stones there are four different kinds. 1. The first has a white colour, and when broken, presents crystalline plates, or striæ, brilliant and white like mica, and having a soft greasy feel. Sometimes its colour is yellow or greenish, and it has constantly a nucleus of inspissated bile. Its specific gravity is inferior to that of water. Gren found the specific gravity of one, 0.803. When exposed to a heat considerably greater than that of boiling water, this crystallized calculus softens and melts, and crystallizes again when the temperature is lowered. It is altogether insoluble in water; but hot alcohol dissolves it with facility. Alcohol of the temperature of 867° dissolves one-twentieth of its weight of this substance; but alcohol at the temperature of 60°, scarcely dissolves any of it. As the alcohol cools, the matter is deposited in brilliant plates, resembling talc, or boracic acid. It is soluble in oil of turpentine. When melted, it has the appearance of oil, and exhales the smell of melted wax; when suddenly heated, it evaporates altogether in a thick smoke. It is soluble in pure alkalis, and the solution has all the properties of a soap. Nitric acid also dissolves it, but it is precipitated unaltered by water. This matter, which is evidently the same with the crystals Cadet obtained from bile, and which he considered as analogous to sugar of milk, has a strong resemblance to spermaceti. Like that substance, it is of an oily nature, and inflammable; but it differs from it in a variety of particulars. Since it is contained in bile, it is not difficult to see how it may crystallize in the gall-bladder if it happen to be more abundant than usual; and the consequence must be a gall-stone of this species. Fourcroy found a quantity of the same substance in the dried human liver. He called it adipocere. 2. The second species of biliary calculus is of a round or polygonal shape, often of a grey colour externally, and brown within. It is formed of concentric layers of a matter which seems to be inspissated bile; and there is usually a nucleus of the white crystalline matter at the centre. For the most part, there are many of this species of calculus in the gall-bladder together; indeed it is frequently filled with them. The calculi belonging to this species are often light and friable, and of a brownish-red colour. The gall-stones of oxen used by painters belong to this species.

A°

These are also adipocere. 3. The third species of calculi are most numerous of all. Their colour is often deep brown or green, and when broken, a number of crystals of the substance resembling spermaceti are observable, mixed with inspissated bile. The calculi belonging to these three species are soluble in alkalis, in soap ley, in alcohol, and in oils. 4. Concerning the fourth species of gall-stone, very little is known with accuracy. Dr. Saunders tells us, that he has met with some gall-stones insoluble both in alcohol and oil of turpentine; some of which do not flame, but become red, and consume to ashes like charcoal. Haller quotes several examples of similar calculi. Gall-stones often occur in the inferior animals, particularly in cows and hogs; but the biliary concretions of these animals have not hitherto been examined with much attention. Soaps have been proposed as solvents for these calculi. The academy of Dijon has published the success of a mixture of essence of turpentine and ether.

GALLITZINITE. Rutile. An ore of Titanium.

GALLS. These are the protuberances produced by the puncture of an insect on plants and trees of different kinds. Some of them are hard, and termed nut-galls; others are soft and spongy, and called berry-galls, or apple-galls. The best are the nut-galls of the oak, and those brought from Aleppo are preferred. These are not smooth on the surface, but tubercular, small, and heavy, and should have a bluish or blackish tinge. Deyeux investigated the properties of galls with considerable care, and more lately Sir H. Davy has examined the same subject. The strongest infusion Sir H. Davy could obtain at 56° F. by repeated infusion of distilled water, on the best Aleppo galls, broken into small pieces, was of the specific gravity of 1·068. Four hundred grains of this infusion, evaporated at a heat below 200°, left 53 of solid matter, which consisted of about 0·9 tannin, and 0.1 gallic acid, united to a portion of extractive matter. One hundred grains of the solid matter left, by incineration, nearly 4½, which were chiefly calcareous matter, mixed with a small portion of fixed alkali. From 500 grains of Aleppo galls Sir H. Davy obtained, by infusion as above, 185 grains of solid matter, which on analysis appeared to consist of tannin 130; mucilage, and matter rendered insoluble by evaporation, 12; gallic acid, with a little extractive matter, 31; remainder, calcareous earth and saline matter, 12. The use of galls in dyeing is very extensive, and they are one of the principal ingredients in making ink. Powdered galls made into an ointment with hog's lard, are a very efficacious application in piles. They are sometimes given internally as an astringent, and in the intermittents, where the bark has failed. The tubercles, or knots, on the roots of young oaks, are said to possess the same properties as the nut-galls, and to be produced in a similar manner.

GALLIC ACID. This acid is found in different vegetable substances possessing astringent properties, but most abundantly in the excrescences termed galls, or nut-galls, whence it derives its name. It may be obtained by macerating galls in water, filtering, and suffering the liquor to stand exposed to the air. It will grow mouldy, be covered with a thick glutinous pellicle, abundance of glutinous flocks will fall down, and, in the course of two or three months, the sides of the vessel will appear covered with small yellowish crystals, abundance of which will likewise be found on the under surface of the supernatant pellicle. These crystals may be purified by solution in alcohol, and evaporation to dryness. Or muriate of tin may be added to the infusion of galls, till no more precipitate falls down; the excess of oxide of tin remaining in the solution, may then be precipitated by sulphuretted hydrogen gas, and the liquor will yield crystals of gallic acid by evaporation. A more simple process, however, is that of M. Fiedler. Boil an ounce of powdered galls in sixteen ounces of water to eight, and strain. Dissolve two ounces of alum in water, precipitate the alumina by carbonate of potash; and after edulcorating it completely by repeated ablutions, add it to the decoction, frequently stirring the mixture with a glass rod. The next day filter the mixture: wash the precipitate with warm water, till this will no longer blacken sulphate of iron; mix

the washings with the filtered liquor, evaporate, and the gallic acid will be obtained in fine needled crystals. The crystals obtained in any of these ways, however, according to sir H. Davy, are contaminated with a small portion of extractive matter, and to purify them they may be placed in a glass capsule in a sand heat, and sublimed into another capsule, inverted over this and kept cool. M. Deyeau indeed, recommends to procure the acid by sublimation in the first instance; putting the powdered galls into a glass retort, and applying heat slowly and cautiously, when the acid will rise, and be condensed in the neck of the retort. This process requires great care, as, if the heat be carried so far as to disengage the oil, the crystals will be dissolved immediately. The crystals thus obtained are pretty large, laminated, and brilliant. The gallic acid, placed on a red-hot iron, burns with flame, and emits an aromatic smell, not unlike that of benzoic acid. It is soluble in twenty parts of cold water, and in three parts at a boiling heat. It is more soluble in alcohol, which takes up an equal weight if heated, and one-fourth of its weight cold. Concentrated sulphuric acid decomposes and carbonizes it; and the nitric acid converts it into malic and oxalic acids. United with barytes, strontian, lime, and magnesia, it forms salts of a dull yellow colour, which are little soluble, but more so if their base be in excess. With alkalis, it forms salts that are not very soluble in general. Its most distinguishing characteristic is its great affinity for metallic oxides, so as, when combined with tannin, to take them from powerful acids. The more readily the metallic oxides part with their oxygen, the more they are alterable by the gallic acid. To a solution of gold, it imparts a green hue: and a brown precipitate is formed, which readily passes to the metallic state, and covers the solution with a shining golden pellicle. With nitric solution of silver, it produces a similar effect. Mercury it precipitates of an orange yellow; copper, brown; bismuth, of a lemon colour; lead, white; iron, black. Platina, zinc, tin, cobalt, and manganese, are not precipitated by it. The gallic acid is of extensive use in the art of dyeing, as it constitutes one of the principal ingredients in all the shades of black, and is employed to fix or improve several other colours. It is well known as an ingredient in ink.—(See *Galls*, *Dyeing*, and *Ink*.)

GALVANISM.—(See *Electricity*.)

GAMBOGE, is a concrete vegetable juice, the produce of two trees, both called by the Indians caracapulli (gambogia gutta, Lin.), and is partly of a gummy and partly of a resinous nature. It is brought to us either in form of orbicular masses, or of cylindrical rolls of various sizes; and is of a dense compact, firm texture, and of a beautiful yellow. It is chiefly brought to us from Cambaja, in the East Indies, called also Cambodja, and Cambogia; and hence it has obtained its name of cambadium, cambodium, cambogium, gambogium. It is a very rough and strong purge; it operates both by vomit and stool, and both ways with much violence, almost in the instant in which it is swallowed, but yet, as it is said, without griping. The dose is from two to four grains as a cathartic; from four to eight grains prove emetic and purgative. The roughness of its operation is diminished by giving it in a liquid form sufficiently diluted. This gum resin is soluble both in water and in alcohol. Alkaline solutions possess a deep red colour, and pass the filter. Dr. Lewis informs us, that it gives a beautiful and durable citron-yellow stain to marble, whether rubbed in substance on the hot stone, or applied, as dragon's blood sometimes is, in form of a spirituous tincture. When it is applied on cold marble, the stone is afterwards to be heated to make the colour penetrate. It is chiefly used as a pigment in water colours, but does not stand.

GANGUE. The stones which fill the cavities that form the veins of metals, are called gangue, or matrix of the ore.

GARNET. There are various species and sub-species of this mineral. The precious, or noble garnet, is of a colour dark red, falling into blue, of a glistening lustre. Specific gravity 4·0 to 4·2. It consists, according to Berzelius, of 39·66 selica, 19·66 alumina; black oxide of iron, 39·68; oxide of manganese, 1.80. It occurs in northern countries. Valuable gar-

nets are found in Pegu. It is cut for ring stones. Coarse garnets are used for polishing metals. The following composition affords an excellent imitation of garnet :—

Purest white glass	.	2 ounces
Glass of antimony	.	1 ounce
Powder of Cassius	.	1 grain
Manganese	.	1 grain.

The common garnet, on account of its fusibility and richness of iron is frequently used as a flux in smelting iron ores. It is sometimes used instead of emery to polish metals. Brown and green are its most common colours. It consists of 3·8 selica, 20·6 alumina, 31·6 lime, and 10·5 iron. Its lustre is shining, or glistening.

GAS. When any body combines with caloric to such a degree that it assumes the form of air, and is able to retain a permanently elastic form, it is called a gas. When, however, any aeriform substance, by an abstraction of its heat, is reduced or condensed, so as to lose its elasticity, and thereby resume its liquid form, it is termed vapour. A very familiar example of the former is the air we breathe ; and of the latter, we may adduce the aeriform state of steam from boiling water. The latter is liable to condensation ; whereas the former cannot be made to change its state by any means at present known. The gases form a very numerous class of chemical bodies, and possess properties the most wonderful, and opposite to each other. They possess weight, like other bodies, their specific gravities being ascertained by comparison with that of air, as those of liquids and solids are by the gravity of water. Gases are generally colourless, but not always so, as in the case of chlorine. Many of the compound gases exhale peculiar odours. But the properties which best serve to distinguish them from each other, are the relative powers which they possess in supporting combustion and animal life. Various solid and liquid substances possess the property of absorbing gases. Of these, charcoal is the most powerful. All porous bodies possess this property more or less. If a piece of charcoal be saturated with oxygen, hydrogen, azote or carbonic, and is put into another gas, it allows part of the first to escape, in order to make room for a portion of the second Two gases united by absorption in charcoal, often experience a greater condensation than each would in a separate state. All gases are absorbed by liquids, and again separated by heat, or the diminution of external pressure.—For further particulars see *Carbonic Acid Gas, Coal Gas, Oxygen, Hydrogen, Nitrogen*, and other gases, under their respective heads.

GASTRIC JUICE, is separated by glands placed between the membranes which line the stomach ; and from these it is emitted into the stomach itself.

From various experiments it follows :

1. That the gastric juice reduces the aliments into a uniform magma, even out of the body, and in vitro ; and that it acts in the same mannre on the stomach after death ; which proves that its effect is chemical, and almost independent of vitality. 2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration. 3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals with a muscular stomach, such as ducks, geese, pigeons, &c. Some of these animals, bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs. Spallanzani has ascertained, that flesh, included in spheres sufficiently strong to resist the muscular action, was completely digested. 4. That gastric juice acts by its solvent power, and not as a ferment ; because the ordinary and natural digestion is attended with no disengagement of air, or inflation, or heat, or, in a word, with any other of the phenomena of fermentation.

GEHLANITE. A mineral substance, resembling Vesuvian.

GELATIN, GELLY or JELLY, an animal substance, soluble in water, capable of assuming a well-known elastic or tremulous consistence, by cooling, when the water is not too abundant, and liquefiable again by increasing its temperature. This last property distinguishes it from albumen, which becomes consistent by heat. It

is precipitated in an insoluble form by tannin, and it is this action of tannin on gelatine that is the foundation of the art of tanning leather. See GLUE.

According to the analysis of MM. Gay. Lussac and Thenard, gelatin is composed of

Carbon	- -	47.881
Oxygen	- -	27.207
Hydrogen	-	7.914
Azote	- -	16.998
		100.000

GEMS. This word is used to denote such stones as are considered by mankind as precious. These are the diamond, the ruby, the sapphire, the topaz, the chrysolite the beryl, the emerald, the hyacinth, the amethyst, the garnet, the tourmalin, the opal; and to these may be added, rock crystal, the finer flints of pebbles, the cat's eye, the oculus mundi, or hydrophanes, the chalcedony, the moon-stone, the onyx, the carnelian, the sardonyx, agates, and the Labrador-stone; for which consult the several articles respectively.

GEODES. A kind of ætites, the hollow of which, instead of a nodule, contains only loose earth, and is commonly lined with crystals.

GEOLOGICAL CHANGES. On viewing the terrestrial globe, and observing what changes its surface has undergone, it is scarcely possible to restrain the activity of the imagination; we are almost irresistibly led to speculate concerning its past and future condition. The theory of Werner considers that all the superficial parts of the globe were once in a state of aqueous solution, from which the materials were at first separated by chemical deposition in a chrystaline state, and formed a thick mass of granite round the globe. Upon granite the primary rocks were successively deposited, forming layers over each other, like the coats of an onion. Over these again were laid the transition rocks; and next the earthy stratified rocks. Each of these layers is supposed to encircle the globe, or to be an universal formation. During this process, the waters were gradually retiring, and became turbid; hence the materials they deposited to form the upper strata were more earthy than those of the primary rocks, and also intermixed with fragments of the rocks previously formed. According to this system, mountains and valleys were caused by the original inequality of the earth's nucleus. Three-fifths of the earth's surface, says Bakewell, are covered by the sea, at the average depth of ten miles; but great changes have taken place in the relative positions of the present continents with the ocean, which, in former ages, rolled its waves over the summits of our highest mountains. Of this, demonstrative proofs exist in our own island, and in various parts of the world. The calcareous, or limestone, mountains in Derbyshire, and Craven in Yorkshire, rise about 2,000 feet above the present level of the sea. Yet they contain, through their whole extent, fossil remains of zoophytes, shell-fish, and marine animals; more abundantly in some parts than in others. The mountains of the Pyrenees in the highest part at Mont Perdu, are covered with calcareous rocks, containing impressions of marine animals; and even where the impressions are not visible, the limestone dissolved in acids yields a fetid cadaverous odour, probably because of the animal matter it contains Mont Perdu rises 10,500 feet above the level of the sea; it is the highest European situation where any marine remains have been found. In the Andes they have been observed by Humboldt at the height of 14,000 feet. In England the calcareous mountains contain no remains of vegetables; but the thick beds of shale and gritstone lying upon them, have various vegetable impressions; and above these, regular beds of coal, with strata containing shells of fresh-water mussels. The earthy limestone of the upper strata has sometimes fossil flat-fish, with the impressions of the scales and bones quite distinct; and lastly, in and under the thick beds of clay, covering chalk, in the southern countries, the bones of the rhinoceros, the elephant, and the mammoth, have been discovered. The sagacious naturalist Cuvier, has attentively examined these bones from different parts of the world, and observed characteristic variations of structure, proving that they belong to animals not now existing on our globe: and seldom are any of the various zoophytes and shell-fish found in calcareous rocks, discovered in our

present seas. The fossil remains of animals not now in existence, entombed and preserved in solid rocks, afford us durable monuments of the great changes, which in former ages our planet has undergone. We are led to a period when the waters of the ocean covered the summits of our highest mountains; and are irresistibly compelled to admit one of two conclusions; either, that the sea has retired and sunk below its former level; or some power operating beneath, has lifted up from the watery abyss to their present elevation above its surface, the islands and continents, with all their hills and mountains. Geology, or the study of the earth, says Mr. W. Phillips, may be regarded as altogether modern, as a science. Until near the end of the last century, it was little understood; perhaps, because chemistry and mineralogy, on which it greatly depends, had not made any large advances towards their present state. In Burnet's opinion, the whole earth consisted of an uniform light crust, which covered the abyss of the sea; and which, being broken, for the production of the deluge, formed the mountains by its fragments. According to Woodward, the deluge was occasioned by a momentary suspension of cohesion among the particles of mineral bodies; the whole mass of the globe was dissolved, and the soft paste became penetrated by shells. Whiston fancied that the earth was created from the atmosphere of one comet, and deluged by the tail of another. The great Leiblitz, like Descartes, amused his imagination, by conceiving the world to be an extinguished sun, or a vitrified globe; upon which, the vapours, condensing as it cooled, formed seas, and afterwards deposited calcareous strata. Demaillet conceived the globe to have been many thousand years covered with water, which gradually retired; that all the terrestrial animals were originally inhabitants of the sea; that man himself began his career as a fish. Buffon imagined that the mass of our earth, together with those of the other planets, were struck off the sun, in a liquefied state, by a comet, at the same instant. Some modern philosophers have supposed every thing to have been originally fluid; this universal fluid gave existence to animals of the simplest kind; in process of time, the races of these animals became complicated, and, dying, supplied calcareous earth or lime; that aluminous earth or clay was supplied by the decay of vegetables. That these two earths were redissolved by a final analysis into silex; hence that the more ancient mountains are siliceous; making the solid parts of our globe owe their existence to animal or vegetable life; which without it would have continued entirely liquid. Kepler, one of the greatest astronomers, considered the globe as possessed of living faculties, and a circulating vital fluid; that all its particles are alive, and possess instinct and volition, whence their attraction and repulsion: that the organs through which the huge animal breathes, are the mountains; that mineral veins are abscesses; and metals the product of rottenness and disease. Marschall supposes the fragments of which the surface of the earth is composed, to have fallen from heaven. Bertrand has supposed that the earth is hollow, and contains a loadstone, dragged from one pole to the other by comets; so as, by changing its centre of gravity, to drown alternately the two hemispheres. Jameson, now a professor of natural history in one of our own universities, has lately published this amusing query: "As the true figure of the earth is still unascertained, may we not conjecture, from what is already known, that it is a polyedron (a figure of many sides), and that the strata, under determinate angles, form the sides and cleavage of this great crystal?" Amongst the various theories by far the most ingenious and interesting, is that of Sir Richard Phillips. The facts, says he, collected and published by Parkinson, Cuvier, Webster, Werner, and Farey, relative to the quantities, varieties, and systematic dispositions of the fossil remains of animated and vegetable nature, which flourished in periods of obscure and remote antiquity, have long deeply interested every thinking person. It must be evident to every one who has compared the aspect of the sea-coast with that of the interior of a country, and examined the strata beneath the surface, that the surface of the latter must also have been exposed to the action of the sea, or have been covered by the sea;—it is known

by observation that, beneath the undulations of the soil, are to be found alternate strata of the remains of marine productions, and of land-animals and vegetables;—and it is notorious that these remains often consist, in northern latitudes, of animals and vegetables peculiar now to the tropics. It appears also, that the processes employed in producing these changes must severally have occupied, in the ordinary course of nature, many thousand years. The Emperor Joseph II. in order to ascertain the period in which subterraneous wood petrifies, caused some of the piles of Trajan's bridge, built 1600 years before, to be taken up; when it was found that the petrifying process had penetrated the timbers but an inch: and it was thence calculated that ten thousand years must elapse before such a solid petrifaction could be produced, as is very commonly found. The globe itself must have existed for an indefinite time anterior to the common interpretations of the Mosaic chronology, which erroneously construe the phrase "in the beginning," to mean a definite point of time; whereas it properly means, at the first indefinitely, perhaps millions of years or ages before the subsequent detailed history. No person who views the fossil remains of destroyed countries, who considers the remains of strata upon strata, and who contemplates the combinations which must have united in various epochs, can hesitate to admit, that, without miracles for these special purposes, such phenomena could not have been produced in less than many thousand years; and, in collateral proof of this deduction from natural appearances, we may refer to the traditions of antiquity, and to the existing records of eastern nations. Should I be able, says sir Richard, however, to adduce a series of natural causes—of great and never-failing causes—of causes equal to the effects—and of causes which must have acted, and must have produced all these effects, at intervals of ten thousand years; the concurrence of phenomena, of tradition, of effect, and of these necessary causes, will, I should imagine, amount to something like demonstration in proof of the great age of the globe. To account for these phenomena on the surface of the earth (the surface alone being all that concerns the emmet man, and the sole object of these speculations), it is necessary simply to refer to the physical effects produced on that surface by the regular changes in the forces which produce the earth's motions as a planet. To those regular planetary motions may easily be referred all the changes in the phenomena of the surface, which have occasioned so much difficulty in the finite and local examinations of geologists. It is unnecessary, however, in the course of such a developement, to turn from the general argument, to discuss exceptions arising from local or temporary combinations; and it ought to satisfy curiosity, if I illustrate the general and overbearing causes of the phenomena,—causes which it may be shown *a posteriori* are equal to the effects,—and from which the effects might, at any time, have been anticipated *a priori*, had the causes been understood before the effects took place. Two motions of the earth, not difficult to be understood, may solve all the enigmas which have long embarrassed these questions. Due regard to their influence will show that changes, like those that have past, will inevitably take place again and again; that like causes must and will produce similar effects; that the fair regions which we now inhabit must, in the regular course of nature, be covered again by the ocean; that new layers of marine productions of sand, gravel, and broken mountains, will overwhelm that soil to which we now feel such lively attachment; and, finally, that new countries, or arrangements of land, will again arise in due course in those mundane sites which at present are occupied by civilized Europe, and by the northern parts of Asia and America. When the earth is in that part of its orbit nearest to the sun, it is then said to be in its perihelion, and is four millions of miles nearer to the sun than when at the opposite point. When in its perihelion, the action or momentum of the sun, or the centripetal force, is increased nearly one fifteenth; and, in consequence, the orbicular velocity carries it through sixty-one minutes per day, instead of fifty-seven minutes, its motion at the aphelion distance, or 59 min. its mean motion. This increased motion, and

all the combined forces, necessarily generate an increase in the tides, and accumulate a body of waters towards that parallel of the earth, in which lies the direction of the forces. All the economy of the waters may then be said to be stimulated to vigorous or increased action, and an unusual bustle and energy, if such terms can be applied to the grandeur of nature, take place in the elements of air and water, whether they are considered as agents or patients. Hence then it doubtless is, that in this age so vast and extensive a body of water surrounds the south pole, extending even to the thirtieth degree of south latitude, and leaving no considerable surface of land in the whole southern hemisphere. The waters are at this time, therefore, by the peculiar modification of the forces, impelled or moved in masses into that hemisphere, to accommodate, by the increased momentum of their oscillations, the increased centripetal force of the earth in its perihelion, which in this age happens on the last day of December, while the sun is passing vertically over 23 deg. of south latitude. In that southern parallel, consequently, lies the direction of the maxima of the centripetal and reacting forces. If then the earth were always in its perihelion on that day, these effects would always happen in the southern hemisphere, and that hemisphere would always have an excess of water, and the northern hemisphere an excess of land. We need not turn aside to remark, that in truth the water is the agent whose vigorous action, in these extended seas, increases the earth's momentum, and shortens its gaseous lever; for it is the local action of the water on the land which we are considering, and not its general agency. Nor is it necessary to remark on such minor topics as the acute angles of the southern continents, and their barriers of indurated rocks, and the contrary forms of the northern continents; nor on various facts in proof that the sea has formed its own beds in that hemisphere. These subjects have been discussed in developing the theory of elliptic orbits. By a suitable combination of the mundane forces, however, the point of the perihelion is forced onward, or rather the earth does not arrive at its perihelion point every year at the same place, by about one minute two seconds of a degree of the ecliptic, making a degree and forty-three minutes in the course of a century; a whole sign in 1744 years, a quarter of a circle in 5233 years; and the round of the whole ecliptic in 20,931 years. Here then are new and striking data for terraqueous epochs and revolutions! Here are great cycles for progressive change, surprising in their results, but imperceptible to man; of which each gradation is 5233 years; in which the opposite effects are produced only in every 10,460 years, and in which the same effects can recur only in every 20,900 years. With a terrestrial globe and an ephemeris before me, I will note the four times, past and to come, in which the perihelion point advanced, or will advance, through 11¾ degrees of declination, producing sensible variations when compared with the middle of each former period. The present epoch of great southern declination will last till the perihelion point arrives at 17¾ degrees of south declination, i. e., it will continue during the progress of that point through four complete signs, or 6977 years, of which (as the sun's perihelion is in 9¾ degrees of Capricorn) 4070 years have already expired. No considerable change then has taken place since the year 2258, B. C., and none will occur from this cause till about the year 4719. The second epoch is that which arises from the passage of the perihelion point through the declination from 11¾ south, to the equator, and this will last while it passes through the single sign Pisces, or 1744 years; i. e., between the years 4719 and 6463. Referring to the past, it occurred 5814 years ago, or 4032 before Christ, or the very date of the Mosaic creation. The third epoch is that which passes while the perihelion point is moving from the equator to 11¾ degrees of north declination, or while in ascending it moves through Aries, making 1744 years, and extending from the year 6463 to the year 8207. Referring to times past, it included the passage through Virgo, extending to 5746 years B. C. The fourth period will last as long as the first or present period, or during the passage of the perihelion point through the

four northern signs, or during 6977 years, i. e., from the year 8207 to 15,184; and referring to past times, this epoch occurred between the years 5746 B. C. and 12,723 B. C. In every 20,931 years the same periods and phenomena are, of course, repeated, from the recurrence of the same causes. In remarking on these grand natural epochs, it is evident that we are now, in 1821, advanced beyond the middle of a period of nearly 7000 years: during which time the maxima of the action and re-action of the solar and mundane forces lie in the southern hemisphere, and consequently accumulate the waters in that hemisphere, deluging, overwhelming, and changing the surface of all the land; an operation which has been proceeding during at least 4000 years past, and which will continue for other 3000 years with little abatement of cause or force. Of course, during this prodigious time, a contrary effect has taken place in the northern hemisphere, from which the waters have been drawn off to produce the re-action, and the balance of forces required in the southern hemisphere by the perpendicularity of the perihelion to that hemisphere. The second and third periods of 1744 years each may not improperly be joined in one ascending, and one descending, of 3488 years. This may be said to be the period of the grand and operative transit of the forces from the northern to the southern hemisphere. It was in some part of this epoch, doubtless in its middle, on passing through the signs Virgo and Libra equator, that the last great changes took place, and established our northern hemisphere. This happened, as stated, 1002 years before Christ, a fractional period, sooner or later, as the perihelion point at that time passed the equator towards the south. Then it doubtless was that the earth (the northern hemisphere, of which Moses was treating), "was without form and void, and that the spirit of God moved upon the face of the waters; and that God said, let the waters under the heavens be gathered together unto one place, and let the dry land appear; and it was so. And God called the dry land earth, and the gathering together of the waters called he seas." I have strained nothing in this calculation, in which any person may follow me; and I confess I have been both surprised and delighted at the harmony which I have found to exist between the grand changes, which evidently must have taken place, from the secondary causes described, (about 4002 years before Christ,) compared with the records of the Jewish writings, and all we know of the rude, marshy, and unformed state of these parts of the world, from the accounts of the Greeks and Romans, and even from our own observation in uncultivated tracts. The next time the perihelion point passes the equator, it will be from south to north, in the year of the Christian era 6463, or 4642 years to come; a period so remote, that the very name of Britain will perhaps be forgotten, without any natural convulsions. Nor will it then signify to all who now "fret through life," or to those who succeed during the 150 intervening generations, whether Britain continue to enjoy "her seed-time and harvest-time," or shall lie buried, during the greater part of the next 3000 years, at the bottom of the merciless ocean! It would exceed the compass of an ordinary essay to detail the traditions of the north, south, east, and west, in corroboration of this hypothesis. These might amuse the reader; but astronomy does not stand in need of traditions; its deductions are like those of geometry, and its records and exactness are the finest monuments of the industry and genius of man. The other planetary motion of the earth to which I allude, as applying to part of the phenomena, is the gradual diminution of the obliquity of the ecliptic, the extension of which must have augmented the forces in the perihelion. From the action of the forces, it is necessarily a decreasing series, and is now estimated at only 52 in a century, which would be but a degree in 6923 years. To extend the tropics, therefore, but 10 degrees, would, at this rate, require 69,230 years; or to extend it to 45°, so that Britain might have been in the same relation to the tropics as Morocco and Egypt in our days, would require 149,000 years, or seven revolutions of the perihelion point. It is, however, sufficient for us to know, that in this motion we have a natural explanation of the cause of the exis-

tance of tropical productions in these latitudes. The following observations made during a period of the last 3000 years, show, with tolerable exactness, the progressive diminution of the obliquity of the ecliptic:

	Years ago.	
Tycheou-Kong . .	3000——23°	51
Pytheas	2100——23	50
Chinese *obs.* . . .	2000——23	48
Ptolemy	1650——23	49
Uley Beg	350——23	30
Tycho Brahe . .	220——23	31
Kepler	200——23	30
Flamstead . . .	120——23	
Bradley	60——23	28

In 1820, by Nautical Almanack, 23° 27 min. 57 sec.

Perhaps the phenomena discovered by geologists require no further explication than is afforded by these great astronomical changes. It must be evident that they account for, and are fully equal to the general production of all those phenomena. What may be the actual measure of the accumulation of waters from the action of the maxima of the forces in either hemisphere, during the passage of the perihelion, I have not attempted to calculate; but an average rise of an inch per annum, or eight feet in a century, during twenty-five centuries, would produce a rise of 200 feet perpendicular, which, with an increase of twelve feet from ordinary, and twenty-five feet from spring-tides, would in 2000 years be sufficient to deluge, undermine, and destroy all the lands in either hemisphere, and to produce those beds of shells, and other marine appearances, which have hitherto excited so much astonishment, and which have been involved in such inexplicable mystery. The three alternate strata of marine and land remains, observed by Cuvier, prove that the sea has covered the land at least three times; or, according to this theory, that the perihelion point has made at least three revolutions since the earth has existed in its present form. Every one who views the interior of a country must be sensible that its swelling hills and vallies must have been produced by the action of water. In many inland situations, the cliffs still remain; and the accumulation of shells and fossil remains in particular spots, prove that the tides for centuries wafted every thing moveable to those points. The economy by which water forms land, even above its own level, is well understood by all who have witnessed what passes on the sea-shore, in situations where the sea is gradually retreating. In short, every fact supports the mechanical hypothesis, and tends to prove that all changes of matter, whether great or small, originate with great motions, which create small and specific ones, while these serve as the proximate causes of local and particular phenomena. —The knowledge of the structure, composition, and arrangement of the materials which form mountains, rocks, or strata constitutes the *first* part of the science called Geology.—In the *second* part, we may include the direction, structure, and extent of the mineral dykes and metallic veins by which they are intersected.—In the *third* part, the changes which are taking place on the surface of the globe by the agency of inundations, earthquakes, and volcanoes.—There is a *fourth* part, which may be styled speculative geology, or an investigation of the causes that have probably operated in the formation of rocks and mountains, and also those by which the revolutions of the earth's surface have been subsequently affected. Nor is this part, as some assert, entirely useless; the advocates of particular systems have engaged in an active examination of nature to support their opinions, and have "compassed sea and land to gain proselytes:" thus numerous facts have been discovered, with which we should not have been acquainted had they remained idle in their studies. It may, however, be doubted, whether they have not sometimes been insensibly induced to close their eyes on other facts that opposed their favourite theories.

General Conclusions, by Mr. W. Phillips, in his Outlines of Geology and Mineralogy.

1. The *lowest and most level* parts of the earth consist of horizontal strata, composed of various substances, many of them containing marine productions.—2. *Similar strata are found in hills* to a great height.—3. Shells are sometimes so numerous as to constitute an entire stratum.—4. Shells are found in elevations *far above the level of the sea,* and at heights to

which the sea could not be raised by any existing cause.—5. These shells once lived in the sea, and were deposited by it.—6. Shells continue to be found as we rise to the foot of *great chains of mountains.*—7. At this elevation, the strata, instead of being horizontal, as in plains, have various degrees of inclination, and are sometimes vertical.—8. From these and other circumstances we infer that there have been frequent irruptions and retreats of the sea. 9. As we approach the *summits of lofty mountains*, the remains of marine animals and shells become rare, and even wholly disappear.—10. Their strata are wholly different, and contain no vestige of a living creature.—11. These strata are, by some, considered as not precisely in the place where they were formed.—12. Nevertheless, as they contain no vestige of animal remains, they are considered the oldest rocks, and are called *primitive.*—13. Rocks termed *primitive*, because including no vestige of animal remains, are of various kinds.—14. Rocks, enclosing animal remains, are never found underneath, or supporting, those rocks termed *primitive.*—15. Some primitive rocks alternate with each other, but granite is found beneath, and frequently overtops all others.—16. Rocks which include organic remains must have been formed *after* the shells they contain; and, *therefore*, not being considered *primitive*, are by some termed *secondary rocks*: hence geologists speak of *primary* and *secondary formations.*—17. There are many varieties of *secondary* rocks, each of which has received a geological appellation.—18. There exists another class of substances, not appropriately termed *rocks*; but the *debris* or ruin of rocks, by long exposure to the action of air and water, are therefore termed *alluvial deposits.*—19. The surface of the globe has been subject to numerous catastrophes: some of which have not been owing to irruptions of the sea, but to the agency of fresh water; and these irruptions of *fresh and of salt water* have been *alternate.*—20. Certain deposits are always found *beneath*, *never above*, certain other deposits. Rocks which contain *no animal remains* are always found *beneath*, *never resting upon*, those rocks, which *do contain animal remains*; and those deposits termed *alluvial*, as gravel, sand, clay, &c. are never found *beneath* other rocks, but always *resting upon* them.—For further remarks, see *Primary Rocks, Secondary Rocks, Transition Rocks, Alluvial Ground, and Volcanoes.*

GERMINATION. The vital developement of a seed, when it first begins to grow.

GILDING. The art of covering the surface of bodies with gold.

The gold prepared for painting is called shell-gold or gold powder, and may be obtained by amalgamating one part of gold with eight of quicksilver, and afterward evaporating the latter, which leaves the gold in the form of powder; or otherwise the metal may be reduced to powder by mechanical trituration. For this purpose, gold leaf must be ground with honey or strong gum-water for a long time; and when the powder is sufficiently fine, the honey or gum may be washed off with water.

GLASS, the different kinds of, manufactured in England at present, are;—1. Flint Glass. 2. Plate Glass. 3. Crown Glass. 4. Broad Glass. 5. Bottle Glass.

The ingredients used by the principal manufacturers of flint glass, are,

Purified Lynn sand	100 parts
Red lead	6
Purified pearlash	3

A little manganese is often added to correct the green colour which may arise from the combustible matter or oxides of iron. Arsenic and nitre are sometimes used.

Plate glass, which is so valuable, and is used for looking glasses, or windows where expense is disregarded, is made from the following materials:—

Pure sand	43
Dry subcarbonate of soda	26·5
Pure quick lime	4
Nitre	1·5
Broken plate glass	25
	100

Which will yield seventy parts of glass.

Crown glass, or window glass is made from fine sand, impure barilla or kelp. Five parts of sand and eleven of kelp by measure are usually employed. But there is a great difference in the kinds of kelp.

Broad glass is made from soap-boilers' waste, kelp and sand. The soap-boilers' waste consists of lime used for making the alkali caustic, the insoluble matter of the alkali, and a quantity of salt and water.

Bottle glass is the coarsest of all, and is made from soap-boilers' waste and river sand, in such proportions as the nature of the waste must determine. Common sand and lime, with a mixture of clay and sea salt, form a cheap mixture for bottle glass.

As far as observation has hitherto directed us, it appears to be a general rule, that the hardness, brittleness, elasticity, and other mechanical properties of congealed bodies, are greatly affected by the degree of rapidity with which they assume the solid state. This, which no doubt is referable to the property of crystallization, and its various modes, is remarkably seen in steel and other metals, and seems to obtain in glass. When a drop of glass is suffered to fall into water, it is found to possess the remarkable property of flying into minute pieces, the instant a small part of the tail is broken off. This, which is commonly distinguished by the name of Prince Rupert's drop, is similar to the philosophical phial, which is a small vessel of thick glass suddenly cooled by exposure to the air. Such a vessel possesses the property of flying in pieces, when the smallest piece of flint or angular pebble is let fall into it, though a leaden bullet may be dropped into it from some height without injury. Many explanations have been offered, to account for these and other similar appearances, by referring to a supposed mechanism or arrangement of the particles, or sudden confinement of the matter of heat. The immediate cause, however, appears to be derived from the fact, that the dimensions of bodies suddenly cooled remain larger, than if the refrigeration had been more gradual. Thus the specific gravity of steel hardened by sudden cooling in water is less, and its dimensions consequently greater than that of the same steel gradually cooled. It is more than probable, that an effect of the same nature obtains in glass; so that the dimensions of the external and suddenly cooled surface remain larger than are suited to the accurate envelopement of the interior part, which is less slowly cooled. In most of the metals, the degree of flexibility they possess, must be sufficient to remedy this inaccuracy as it takes place; but in glass, which, though very elastic and flexible, is likewise excessively brittle, the adaptation of the parts, urged different ways by their disposition to retain their respective dimensions, and likewise to remain in contact, by virtue of the cohesive attraction, can be maintained only by an elastic yielding of the whole, as far as may be, which will therefore remain in a state of tension. It is not therefore to be wondered at, that a solution of continuity of any part of the surface should destroy this equilibrium of elasticity; and that the sudden action of all the parts at once, of so brittle a material, should destroy the continuity of the whole, instead of producing an equilibrium of any other kind.

Though the facts relating to this disposition of glass too suddenly cooled, are numerous and interesting to the philosopher, yet they constitute a serious evil with respect to the uses of this excellent material. The remedy of the glass-maker consists in annealing the several articles, which is done by placing them in a furnace near the furnace of fusion. The glasses are first put into the hottest part of this furnace, and gradually removed to the cooler parts at regular intervals of time. By this means the glass cools very slowly throughout, and is in a great measure free from the defects of glass which has been too hastily cooled.

M. Reaumur was the first who made any direct experiments upon the conversion of glass into porcelain. Instances of this effect may be observed among the rubbish of brick-kilns, where pieces of green bottles are not unfrequently subjected by accident, to the requisite heat; but the direct process is as follows: A vessel of green glass is to be filled up to the top with a mixture of white sand and gypsum, and then set in a large crucible upon a quantity of the same mixture, with which the glass vessel must also be surrounded and covered over, and the whole pressed down rather hard. The crucible is then to be covered with a lid, the junctures well luted and put into a potter's kiln, where it must remain during the whole time that the pottery is baking; after which, the glass

vessel will be found transformed into a milk-white porcelain. The glass, on fracture, appears fibrous, as if it were composed merely of silken threads laid by the side of each other: it has also quite lost the smooth and shining appearance of glass, is very hard, and emits sparks of fire when struck with steel, though not so briskly as real porcelain. Lewis observed, that the above-mentioned materials have not exclusively this effect upon glass; but that powdered charcoal, soot, tobacco, pipe clay, and bone-ashes, produce the same change. It is remarkable, that the surrounding sand becomes in some measure agglutinated by this process, which, if continued for a sufficient length of time, entirely destroys the texture of the glass, and renders it pulverulent.

The ancient stained glass has been much admired, and beautiful paintings on this substance have been produced of late years. The colours are of the nature of those used in enamelling, and the glass should have no lead in its composition. Mr. Brogniart has made many experiments on this subject. The purple of Cassius, mixed with six parts of a flux composed of borax and glass made with silex and lead, produces a very beautiful violet, but liable to turn blue. Red oxide of iron, prepared by means of the nitric acid and subsequent exposure to fire, and mixed with a flux of borax, sand, and a small portion of minium, produces a fine red. Muriate of silver, oxide of zinc, white clay, and the yellow oxide of iron, mixed together without any flux, produce a yellow, light or deep, according to the quantity laid on, and equal in beauty to that of the ancients. A powder remains on the surface after baking, which may easily be cleaned off. Blue is produced by oxide of cobalt, with a flux of silex, potash, and lead. To produce a green, blue must be put on one side of the glass, and yellow on the other; or a blue may be mixed with yellow oxide of iron. Black is made by a mixture of blue with the oxides of manganese and iron. The bending of the glass and alteration of the colours, in baking, are particularly to be avoided, and require much care. Gypsum has been recommended for their support, but this frequently renders the glass white, and cracked in all directions, probably from the action of the hot sulphuric acid on the alkali in the glass. Mr. Brogniart placed his plates of glass, some of them much larger than any ever before painted, on very smooth plates of earth or porcelain unglazed, which he found to answer extremely well.

GLAUBER SALT, is native sulphate of soda. Its constuents are 67 soda, carbonate of soda 16·33, muriate of soda 11, carbonate of lime 5·64. It is found along with rock salt, and dissolved in the waters of the ocean.

GLAUBERITE, a mineral consisting of dry sulphate of lime 49, dry sulphate of soda 51.

GLAZING.—*(See Pottery.)*

GLIMMER, a name given to micaceous earths.

GLOBULAR structure in mineralogy is, when rocks consist of balls of different sizes, frequently concentric spherical layers, sometimes detached, at other times imbedded in rocks of the same kind.

GLUCINA. This earth was discovered by Vauquelin, first in the aqua marina, and afterwards in the emerald, in the winter of 1798. Its name is derived from its distinguishing character of forming with acids salts that are sweet to the taste. The following is his method of obtaining it:—Let 100 parts of beryl, or emerald, be reduced to a fine powder, and fused in a silver crucible with 300 of pure potash. Let the mass be diffused in water, and dissolved by adding muriatic acid. Evaporate the solution, taking care to stir it toward the end: mix the residuum with a large quantity of water, and filter, to separate the silex. Precipitate the filtered liquor which contains the muriates of alumina and glucina, with carbonate of potash; wash the precipitate, and dissolve it in sulphuric acid. Add a certain quantity of sulphate of potash, evaporate, and crystals of alum will be obtained. When no more alum is afforded by adding sulphate of potash and evaporating, add solution of carbonate of ammonia in excess, shake the mixture well, and let it stand some hours, till the glucina is re-dissolved by the excess of carbonate of ammonia, and nothing but the alumina remains at the bottom of the vessel. Filter the solution, evaporate to dryness, and expel the acid from

the carbonate of glucina by slight ignition in a crucible. Thus fifteen or sixteen per cent. of pure glucina will be obtained. Glucina thus obtained, is a white, soft powder, light, insipid, and adhering to the tongue. It does not change vegetable blues. It does not harden, shrink or agglutinate by heat; and is infusible. It is insoluble in water, but forms with it a slightly ductile paste. It is dissolved by potash, soda, and carbonate of ammonia; but not by pure ammonia. It unites with sulphuretted hydrogen. Its salts have a saccharine taste, with somewhat of astringency.

GLUE. An inspissated jelly made from the parings of hides and other offals, by boiling them in water, straining through a wicker basket, suffering the impurities to subside, and then boiling it a second time. The articles should first be digested in lime-water, to cleanse them from grease and dirt; then steeped in water, stirring them well from time to time; and lastly, laid in a heap, to have the water pressed out before they are put into the boiler. Some recommend, that the water should be kept as nearly as possible to a boiling heat, without suffering it to enter into ebullition. In this state it is poured into flat frames or moulds, then cut into square pieces when congealed, and afterwards dried in a coarse net. It is said to improve by age; and that glue is reckoned the best, which swells considerably without dissolving by three or four days infusion in cold water, and recovers its former dimensions and properties by drying. Shreds or parings of vellum, parchment, or white leather, make a clear and almost colourless glue.

GLUTEN, (Vegetable). If wheat-flour be made into a paste, and washed in a large quantity of water, it is separated into three distinct substances; a mucillageous saccharine matter, which is readily dissolved in the liquor, and may be separated from it by evaporation; starch, which is suspended in the fluid, and subsides to the bottom by repose; and gluten, which remains in the hand, and is tenacious, very ductile, somewhat elastic, and of a brown-grey colour. The first of these substances does not essentially differ from other saccharine mucilages. The second, namely, the starch, forms a gluey fluid by boiling in water, though it is scarcely, if at all, acted upon by that fluid when cold. Its habitudes and products with the fire, or with nitric acid, are nearly the same as those of gum and of sugar. It appears to be as much more remote from the saline state than gum, as gum is more remote from that state than sugar. The vegetable gluten, though it existed before the washing, in the pulverulent form, and has acquired its tenacity and adhesive qualities from the water it has imbibed, is nevertheless totally insoluble in this fluid. It has scarcely any taste. When dry, it is semi-transparent, and resembles glue in its colour and appearance. If it be drawn out thin, when first obtained, it may be dried by exposure to the air; but if it be exposed to warmth and moisture while wet, it putrifies like an animal substance. The dried gluten applied to the flame of a candle, crackles, swells, and burns, exactly like a feather, or piece of horn. It affords the same products by destructive distillation as animal matters do; is not soluble in alcohol, oils, or ether; and is acted upon by acids and alkalis, when heated. According to Rouelle, it is the same with the caseous substance of milk. Gluten is found in a great number of plants. Proust discovered it in acorns, chestnuts, horse-chestnuts, apples, and quinces; barley, rye, pease, and beans; likewise in the leaves of rue, cabbage, cresses, hemlock, borage, saffron; in the berries of the elder and of the grape. Gluten appears to be one of the most nutritive of the vegetable substances, and wheat seems to owe its superiority to other grain from its containing it in larger quantities.

GNEISS. A compound rock, consisting of felspar, quartz, and mica, disposed in slates, from the predominance of the mica scales. Its structure is called by Werner, granular-slaty. This geognostic formation is always stratified; contains sometimes crystals of schorl, tourmaline, and garnet, and is peculiarly rich in metallic ores.

GOLD, is a yellow metal, of specific gravity, 19·3. It is soft, very tough, ductile, and malleable; unalterable and fixed, whether exposed to the atmosphere, or to the strongest heat of

CURVED GNEISS IN LEWIS

furnaces. Powerful burning mirrors have volatilized it; and it has been driven up in fumes, in the metallic state, by flame urged upon it by a stream of oxygen gas. The electric shock converts it into a purple oxide, as may be seen by transmitting that commotion through gold leaf, between two plates of glass; or by causing the explosive spark of three or more square feet of coated glass, to fall upon a gilded surface. A heat of 32 deg. W., or perhaps 1300 deg. F., is required to melt it, which does not happen till after ignition. Its colour, when melted, is of a bluish-green; and the same colour is exhibited, by light transmitted through gold leaf. The limits of the ductility and malleability of gold are not known. The method of extending gold used by the gold-beaters, consists in hammering a number of thin rolled plates between skins or animal membranes. By the weight and measure of the best wrought gold leaf, it is found, that one grain is made to cover 56¾ square inches; and from the specific gravity of the metal, together with this admeasurement, it follows, that the leaf itself is $\frac{1}{282000}$ part of an inch thick. This, however, is not the limit of the malleability of gold, for the gold-beaters find it necessary to add three grains of copper in the ounce to harden the gold, which otherwise would pass round the irregularities of the newest skins, and not over them; and in using the old skins, which are not so perfect and smooth, they proceed so far as to add twelve grains. The wire which is used by the lace-makers, is drawn from an ingot of silver, previously gilded. In this way, from the known diameter of the wire, or breadth when flattened, and its length, together with the quantity of gold used, it is found, by computation, that the covering of gold is only one-twelfth part of the thickness of gold-leaf, though it still is so perfect as to exhibit no cracks when viewed by a microscope. No acid acts readily upon gold but aqua regia, and aqueous chlorine. Chromic acid added to the muriatic, enables it to dissolve gold. The small degree of concentration, of which aqueous chlorine is susceptible, and the imperfect action of the latter acids, render aqua regia the most convenient solvent for this metal. When gold is immersed in aqua regia, an effervescence takes place; the solution tinges animal matters of a deep purple, and corrodes them. By careful evaporation, fine crystals of a topaz colour are obtained. The gold is precipitated from its solvent by a great number of substances. Lime and magnesia precipitate it in the form of a yellowish powder. Alkalis exhibit the same appearance; but an excess of alkali re-dissolves the precipitate. The precipitate of gold obtained from aqua regia by the addition of a fixed alkali, appears to be a true oxide, and is soluble in the sulphuric, nitric, and muriatic acids; from which, however, it separates by standing, or by evaporation of the acids. Gallic acid precipitates gold of a reddish colour, very soluble in the nitric acid, to which it communicates a fine blue colour. Ammonia precipitates the solution of gold much more readily than fixed alkalis. This precipitate, which is of a brown, yellow, or orange colour, possesses the property of detonating with a very considerable noise when gently heated. It is known by the name of fulminating gold. The presence of ammonia is necessary to give the fulminating property to the precipitate of gold, and it will be produced by precipitating it with fixed alkali, from an aqua regia previously made by adding sal ammoniac to nitric acid, or by precipitating the gold from pure aqua regia, by means of sal ammonia, instead of the ammonia alone. The fulminating gold weighs one-fourth more than the gold made use of. A considerable degree of precaution is necessary in preparing this substance. It ought not to be dried but in the open air, at a distance from a fire, because a very gentle heat may cause it to explode. Several fatal accidents have arisen from its explosion, in consequence of the friction of ground stoppers in bottles containing this substance, of which a small portion remained in the neck. Fulminating gold, when exposed by Berthollet to a very gentle heat in a copper tube, with the pneumatical apparatus of mercury, was deprived of its fulminating quality, and converted into an oxide at the same time that ammoniacal gas was disengaged. From this dangerous experiment it is

ascertained, that fulminating gold consists of oxide of gold combined with ammonia. The same eminent philosopher caused fulminating gold to explode in copper vessels. Nitrogen gas was disengaged, a few drops of water appeared, and the gold was reduced to the metallic form. In this experiment he infers, that the ammonia was decomposed; that the nitrogen, suddenly assuming the elastic state, caused the explosion, while the oxygen of the oxide united with the hydrogen of the alkali, and formed the water. This satisfactory theory was still farther confirmed by the decomposition of fulminating gold, which takes place in consequence of the action of the concentrated sulphuric acid, of melted sulphur, fat oils, and ether; all which deprived it of its fulminating quality, by combining with its ammonia. Sulphurets precipitate gold from its solvent, the alkali uniting with the acid, and the gold falling down combined with the sulphur; of which, however, it may be deprived by moderate heat. Most metallic substances precipitate gold from aqua regia: lead, iron, and silver, precipitate it of a deep and dull purple colour; copper and iron throw it down in its metallic state; bismuth, zinc, and mercury, likewise precipitate it. A plate of tin, immersed in a solution of gold, affords a purple powder, called the purple powder of Cassius, which is used to paint in enamel. Ether, naphtha, and essential oils, take gold from its solvent, and from liquors, which have been called potable gold. The gold which is precipitated by evaporation of these fluids, or by the addition of sulphate of iron to the solution of gold, is of the utmost purity. Most metals unite with gold by fusion. With silver it forms a compound, which is paler in proportion to the quantity of silver added. It is remarkable, that a certain proportion, for example, a fifth part, renders it greenish. From this circumstance, as well as from that of a considerable proportion of these metals separating from each other by fusion, in consequence of their different specific gravities, when their proportions do not greatly differ, it should seem, that their union is little more than a mere mixture without combination; for, as gold leaf transmits the green rays of light, it will easily follow, that particles of silver, enveloped in particles of gold, will reflect a green instead of a white light. A strong heat is necessary to combine platina with gold; it greatly alters the colour of the gold, if its weight exceed the forty-seventh part of the mass. Mercury is strongly disposed to unite with gold, in all proportions with which it forms an amalgam: this, like other amalgams, is softer the larger the proportion of mercury. It softens and liquefies by heat, and crystallizes by cooling. Lead unites with gold, and considerably impairs its ductility, one-fourth of a grain to an ounce rendering it completely brittle. Copper renders gold less ductile, harder, more fusible, and of a deeper colour. This is the usual addition in coin, and other articles used in society. Tin renders it brittle in proportion to its quantity; but it is a common error of chemical writers to say, that the slightest addition is sufficient for this purpose. When alloyed with tin, however, it will not bear a red heat. With iron it forms a grey mixture, which obeys the magnet. This metal is very hard, and is said to be much superior to steel for the fabrication of cutting instruments. Bismuth renders gold white and brittle; as do likewise nickel, manganese, arsenic, and antimony. Zinc produces the same effect; and, when equal in weight to the gold, a metal of a fine grain is produced, which is said to be well adapted to form the mirrors of reflecting telescopes, on account of the fine polish it is susceptible of, and its not being subject to tarnish. The alloys of gold with molybdena are not known. It could not be mixed with tungsten, on account of the infusibility of this last substance. Mr. Hatchet gives the following order of different metals, arranged as they diminish the ductility of gold: bismuth, lead, antimony, arsenic, zinc, cobalt, manganese, nickel, tin, iron, platina, copper, silver. The first three were nearly equal in effect; and the platina was not quite pure. For the purposes of coin, Mr. Hatchett considers an alloy of equal parts of silver and copper as to be preferred, and copper alone as preferable to silver alone. The gold coins of Great Britain consist of eleven parts gold and one copper.

GONG. An Indian or Chinese gong

is made of an alloy of twenty parts tin and seventy-eight copper, which is brittle and malleable when it is tempered, and can accordingly be wrought easily; but it becomes hard, elastic, and brittle, when it is allowed to cool in the open air. It is made in the first of those states, and is afterwards rendered elastic and hard. If struck with a hard body it would break; but if struck with a piece of leather, the sound is at first very small, but by vibration it is communicated to the rest of the mass, and becomes a very loud and terrible noise.

GORGONIA NOBILIS, is a coral coloured red by some unknown substance. Its interior consists of gelatine and carbonate of lime.

GOULARD'S EXTRACT, is a saturated solution of subacetate of lead.

GOUTY CONCRETIONS, have been found to consist of uric acid combined with ammonia. They are called chalk-stones. — (See *Urinary Calculus.*)

GRAIN and Seeds are composed chiefly of starch or coagulated mucilage, generally combined with gluten, oil, or albuminous matter; in corn with gluten, in peas and beans with albuminous matter, and in rapeseed, hempseed, linseed, and the kernels of most nuts, with oils. Sir H. Davy found in 100 parts of wheat sown in autumn,

Of starch	77
Of gluten	19

In 100 parts of wheat sown in spring,

Of starch	70
Of gluten	24

In 100 parts of Barbary wheat,

Of starch	74
Of gluten	23

In 100 parts of Sicilian wheat,

Of starch	75
Of gluten	21

Sir H. Davy examined different specimens of North American wheat, all of them have contained rather more gluten than the British. In general the wheat of warm climates abounds more in gluten and in insoluble parts; and it is of greater specific gravity, harder, and more difficult to grind. The wheat of the south of Europe, in consequence of the larger quantity of gluten it contains, is peculiarly fitted for making macaroni, and other preparations of flour in which a glutinous quality is considered as an excellence. In some experiments made on barley, Sir H. Davy obtained from 100 parts of full and fair Norfolk barley,

Of starch	79
Of gluten	6
Of husk	8

The remaining 7 parts saccharine matter

Einhoff has published a minute analysis of barley meal. He found in 3840 parts

Of volatile matter	360
Of albumen	44
Of saccharine matter	200
Of mucilage	176
Of phosphate of lime, with some albumen	9
Of gluten	135
Of husk, with some gluten and starch	260
Of starch not quite free from gluten	2580
Of loss	78

Rye afforded to Einhoff, in 3840 parts, 2520 meal, 930 husk, and 390 moisture; and the same quantity of meal analysed gave,

Of starch	2345
Of albumen	126
Of mucilage	426
Of saccharine matter	126
Of gluten not dried	364

Remainder husk and loss.

Sir H. Davy obtained from 1000 parts of rye, grown in Suffolk, 61 parts of starch, and 5 parts of gluten. 100 parts of oats, from Sussex, afforded him 59 parts of starch, 6 of gluten, and 2 of saccharine matter. 1000 parts of peas, grown in Norfolk, afforded him 501 parts of starch, 22 parts of saccharine matter, 35 parts of albuminous matter, and 16 parts of extract, which became insoluble during evaporation of the saccharine fluid. From 3840 parts of marsh beans *(Vicia faba)* Einhoff obtained,

Of starch	1312
Of albumen	31
Of other matters which may be conceived nutritive; such as gummy, starchy, fibrous matter analogous to animal matter,	1204

TABLE of the Quantities of Soluble or Nutritive Matters afforded by One Thousand Parts of different Vegetable Substances.

ACCORDING TO SIR H. DAVY.

Vegetables.	Whole quantity of soluble or nutritive matter.	Mucilage or Starch.	Saccharine matter or Sugar.	Gluten or Albumen.	Extract, or matter rendered insoluble during evaporation.
Middlesex wheat	955	765	—	190	—
Spring wheat	940	700	—	240	—
Mildewed wheat	210	178	—	32	—
Blighted wheat	650	520	—	130	—
Thick-skinned Sicilian wheat	950	725	—	230	—
Thin-skinned Sicilian wheat	961	722	—	239	—
Wheat from Poland	950	750	—	200	—
North American wheat	955	730	—	225	—
Norfolk barley	920	790	70	60	—
Oats from Scotland	743	641	15	87	—
Rye from Yorkshire	792	645	38	109	—
Common bean	570	426	—	103	41
Dry peas	574	501	22	35	16
Potatoes	from 260 to 200	from 200 to 155	from 20 to 15	from 40 to 30	—
Linseed cake	151	123	11	17	—
Red beet	148	14	121	13	—
White beet	136	13	119	4	—
Parsnip	99	9	90	—	—
Carrots	98	3	95	—	—
Common turnips	42	7	34	1	—
Swedish turnips	64	9	51	2	2
Cabbage	73	41	24	8	—
Broad-leaved clover	39	31	3	2	3
Long-rooted clover	39	30	4	3	2
White clover	32	29	1	3	5
Sainfoin	39	28	2	3	6
Lucerne	23	18	1	—	4
Meadow fox-tail grass	33	24	3	—	6
Perennial rye grass	39	26	4	—	5
Fertile meadow grass	78	65	6	—	7
Roughish meadow grass	39	29	5	—	6
Crested dog's-tail grass	35	28	3	—	4
Spiked fescue grass	19	15	2	—	2
Sweet-scented soft grass	82	72	4	—	6
Sweet-scented vernal grass	50	43	4	—	3
Fiorin	54	46	5	1	2
Fiorin cut in winter	76	64	8	1	3

All these substances were submitted to experiment green, and in their natural states. It is probable that the excellence of the different articles as food will be found to be in a great measure proportional to the quantities of soluble or nutritive matters they afford; but still these quantities cannot be regarded as *absolutely* denoting their value. Albuminous or glutin matters have the characters of animal substances; sugar is more nourishing, and extractive matter less nourishing, than any other principles composed of carbon, hydrogen, and oxygen. Certain combinations likewise of these substances may be more nutritive than others. The Derbyshire miners in win-

ter prefer oat-cakes to wheaten bread; finding that this kind of nourishment enables them to support their strength and perform their labour better. In summer they say oat-cake beats them, and they then consume the finest wheaten bread they can procure. Even the skin of the kernel of oats probaby has a nourishing power, and is rendered partly soluble in the stomach with the starch and gluten. In most countries of Europe, except Britain, and in Arabia, horses are fed with barley mixed with chopped straw; and the chopped straw seems to act the same part as the husk of the oat. In the mill 14lbs. of good wheat yield on an average 13lbs. of flour; the same quantity of barley 12lbs., and of oats only 8lbs. In the south of Europe, hard or thin-skinned wheat is in higher estimation than soft or thick-skinned wheat: the reason of which is obvious, from the large quantity of gluten and nutritive matter it contains. An analysis was made of only one specimen of thin-skinned wheat, so that other specimens may possibly contain more nutritive matter than that in the table: the Barbary and Sicilian wheats, before referred to, were thick-skinned wheats. In England the difficulty of grinding thin-skinned wheat is an objection; but this difficulty is easily overcome by moistening the corn.

GRAINER, is a lixivium used in tanning to give flexibility to the skins. It is obtained by infusing pigeons' dung in water.

GRAMMATITE. *See Termolite.*

GRANATITE. *See Grenatite.*

GRANITE is considered as the foundation rock on which slate rocks and all secondary rocks are laid. From its great relative depth, granite is not frequently met with, except in situations where it appears to have been forced through the more superficial covering of the globe. Granite is a hard rock, whose constituent parts are the three substances, quartz, felspar, and mica, which are more or less perfectly crystallized, and closely united together. The three minerals of which granite is composed vary much in their proportions in different granitic rocks; and often in specimens from the same rock. The crystals are large, or small, or equally intermixed, in one part, and in another part quartz or felspar greatly predominate. Some granites are composed of small grains, and have large crystals of felspar interspersed; these are denominated porphyritic granites.—Specimens of Cornish and Scotch granites are not difficult to procure in London, as they are commonly used for paving-stones. In the former, the felspar is white, in some specimens it is soft and earthy: the mica appears like glistening scales which have a tarnished semi-metallic lustre. The quartz has a vitreous appearance, and is of a light grey colour. In Scotch granite the felspar has more commonly a reddish brown colour. The mica is not unfrequently black and splendent: this distinguishes it at first sight from hornblende, which is sometimes intermixed with this granite. Very small-grained granites can scarcely be distinguished from sandstone. In general, felspar may be considered as forming the most abundant part of granite; it is sometimes in a decomposing state, owing to the potash which frequently forms a constituent part of this mineral. It is not improbable, however, that what is considered as decomposing granite, may, in some instances, be the original state of the rock. Granite is not stratified, but is sometimes separated into tabular masses, which have been mistaken for strata. It is more frequently divided into large masses or blocks, which have a tendency to assume a rhomboidal form. Granite also exists in round masses, which are composed of concentric spherical layers, separated by granite of a less compact kind, and inclosing a harder central nucleus. These globular masses are three or four yards or more in diameter, and are sometimes found detached, and sometimes imbedded in granite of a softer kind: probably the detached globes of granite were also once imbedded in a similar rock, which has been decomposed and worn away. This globular structure is not peculiar to granite. When granite rises high above the surface, it forms lofty peaks and rugged piles, which at a distance resemble immense ruins. According to the German geologists, granite is the lowest of rock formations; but from the observations of D'Aubisson in Auvergne, and of Humboldt in South America, and from various cir-

cumstances we have reason to infer that the source of volcanic fires is far below granite. The highest point at which granite has been seen is the summit of Mont Blanc, in Switzerland, the loftiest mountain in Europe, rising 15,660 feet above the level of the sea, or nearly five times higher than any mountain in England or Wales. It was first ascended by Dr. Picard in 1786, and afterwards by Saussure, who has published a very interesting account of his ascent. Gneiss, micaceous schist, and other slate rocks rest upon its sides: and on the lower declivities of the mountain are vast masses of lime-stone. Many of the mountains in the extensive range of the Andes in South America rise much higher than Mont Blanc, but granite has not been found there in a greater elevation than 11,500 feet, an elevation exceeded by many of the granite mountains in Europe: but the range of the Andes is the seat of active volcanic fires, which appear to have covered the primary mountains with an immense mass of matter ejected by ancient and recent eruptions. In Mexico and New Spain also the granite appears to be nearly covered by basalt, porphyry, and lava, ejected from the numerous volcanos which now exist, or have existed in those countries. To this accumulation of volcanic matter the mountains in South America owe their superior elevation. Chimborasso and Cayambo are the highest mountains in the world; the former rises 21,440 feet, but their summits are vast cones composed of volcanic productions covered with snow. Chimborasso is one mile and one hundred and sixty yards higher than Mont Blanc. The general arrangement of the Andes consists, according to Humboldt, of granite, gneiss, mica, and clay-slate, as in the Alps; but on these are frequently laid porphyry and basalt, "arranged in the form of regular and immense columns, which strike the eye of the traveller like the ruins of enormous castles lifted into the sky." In the eastern parts of the United States, and in Canada, granite is seen near the surface uncovered by other rocks, and does not rise to any great level. The constant occurrence of granite at a lower level in America than in Europe, is a remarkable geological fact. In Europe the principal mountain ranges are granite; as in Scandinavia, the Alps, the Pyrennees, and the Carpathian mountains. In Asia, granite forms a considerable part of the Uralian and Altaic range of mountains, and it appears to compose the principal mountains that have been examined in Africa. Granite contains few beds of other kinds of rock, nor is it so rich in metallic ores as gneiss and micaceous schist. Veins of tin most commonly occur in this rock, and tin-stone is in some situations disseminated through it. Crystals of schorl, topaz, and garnet are sometimes found in granite, and another mineral before described by the name of hornblende is also common in some kinds of granite, as in that which forms the summit of Mont Blanc. Gneiss and granite are sometimes mistaken for each other by the superficial; but they may be distinguished by gneiss being of a slaty structure. Gneiss is sometimes curved, and a curious specimen is exhibited in the plate.

GRANULATION, the method of dividing metallic substances into grains or small particles, in order to facilitate their combination with other substances, and sometimes for the purpose of readily subdividing them by weight. This is done either by pouring the melted metal into water, or by agitating it in a box until the moment of congelation, at which instant it becomes converted into a powder. Various contrivances are used to prevent danger, and insure success, in the several manufactories that require granulation. Copper is granulated for making brass, by pouring it through a perforated ladle into a covered vessel of water with a moveable false bottom. A compound metal, consisting chiefly of lead, is poured into water through a perforated vessel of another kind, for making small-shot, in which the height above the surface of the fluid requires particular adjustment. In a new manufactory of this kind, the height is upwards of 100 feet.

GRAPHITE, (plumbago). There are two species, the scaly and the compact.—(See *Black-lead.*)

GRAVITY, (Specific).—(See *Specific Gravity.*)

GREEK FIRE. This was an invention of the middle ages, which for

many years was kept a secret by the court of Constantinople, and enabled the Greeks, for a time, to resist the arms of the Mahometans. It was employed in battles by land and sea, and on one occasion, was the means of destroying a fleet employed in the siege of Constantinople. It continued to burn under water. The composition is now unknown, and has ceased to be an object of interest from the invention of the more formidable fire of gunpowder. It is thought that it was made of asphaltum, nitre, and sulphur.

GREEN EARTH, is the mineral which furnishes the mountain green of the artists in water colours. The colour is durable, though less bright than that obtained from copper. The green earth of Verona, on analysis, was found to contain 52 silica, 28 oxide of iron, 2 magnesia, 10 potass, and 6 water. It is found in masses, soft, and rather greasy.

GREENSTONE, a rock of the trap formation, consisting of hornblende and felspar, both in the state of grains and small crystals.

GREYWACKE, a coarse kind of slate, which has been so named by the Germans. It is thus described by Dr. Thomson:—"Greywacke is composed of grains of sand, which are of various sizes, and sometimes even approach in magnitude to rolled masses. These are connected together by a basis of clay-slate (common slate), and hence this rock derives its grey colour and solidity. These fragments are sometimes quartz, sometimes a kind of indurated clay-slate, and sometimes flinty slate. The texture of greywacke becomes gradually finer and finer grained, till at last it can no longer be perceived, and a slaty structure succeeds. It then passes into greywacke slate. Greywacke slate is nothing else than a variety of clay-slate; but it may be distinguished from primitive slate by different circumstances. Its colour is usually ash or smoke-grey, seldom showing that greenish or light yellowish grey colour which is so common in primitive slate. It does not show the silvery uninterrupted lustre of primitive slate, but is rather glimmering from interspersed scales of mica. It contains no beds of quartz, but very often veins of that mineral. It contains no crystals of felspar, schorl, tourmaline, garnet, or hornblende; nor beds of granite, chlorite, slate, talc, or magnetic ironstone; it contains petrifactions. The greywacke rocks are stratified: when not covered by any other formation, they form round backed hills, usually insulated at top, and intersected by deep vallies. It contains immense beds of transition lime-stone, trap, and flint-slate. It is rich in ores, both in beds and veins, and the veins are often of an uncommonly large size."

GUANO, a substance found on many of the small islands in the South Sea, which are the resort of numerous flocks of birds, particularly of the ardea and phœnicopteros genus. It is dug from beds fifty or sixty feet thick, and used as a valuable manure in Peru, chiefly for Indian corn. It is of a dirty yellow colour, nearly insipid to the taste, but has a powerful smell, partaking of castor and valerian. According to the analysis of Fourcroy and Vauquelin, about one-fourth of it is uric acid partly saturated with ammonia and lime. It contains likewise oxalic acid, partly saturated with ammonia and potash; phosphoric acid combined with the same bases and with lime; small quantities of sulphate and muriate of potash, and ammonia; a small portion of fat matter; and sand, partly quartzose, partly ferruginous.

GUIACUM, is a gum resin, extracted from a West Indian tree called the guiacum officinale. A small part is soluble in water, the rest in alcohol. It is used in medicine for syphilis, and other complaints; chiefly in rheumatism, dissolved in ammonia.

GUM. The principal gums are, 1. The common gums, obtained from the plum, the peach, the cherry-tree, &c.—2. Gum Arabic, which flows naturally from the acacia in Egypt, Arabia, and elsewhere. This forms a clear transparent mucilage with water.—3. Gum Seneca, or Senegal. It does not greatly differ from gum Arabic: the pieces are larger and clearer, and it seems to communicate a higher degree of the adhesive quality of water. It is much used by calico-printers and others. The first sort of gums are frequently sold by this name, but may be known by their darker colour.—4. Gum Adragant, or Tragacanth. It is obtained from a small plant of the

same name growing in Syria, and other eastern parts. It comes to us in small white contorted pieces resembling worms. It is usually dearer than other gums, and forms a thicker jelly with water. Mr. Willis has found that the root of the common blue-bell, hyacinthus non scriptus, dried and powdered, affords a mucilage, possessing all the qualities of that from gum Arabic. Lord Dundonald has extracted a mucillage also from lichens. Gums treated with nitric acid afford the acid of sugar.

GUM (Elastic).—(See *Caoutchouc*).

GUM RESIN. The principal gum resins are frankincense, scammony, asafœtida, aloes, gum ammoniac, and gamboge.

GUNPOWDER. This well known powder is composed of 75 parts, by weight, of nitre, 16 of charcoal, and 9 of sulphur, intimately blended together by long pounding in wooden mortars, with a small quantity of water. This proportion of the materials is the most effectual. But the variations of strength in different samples of gunpowder are generally occasioned by the more or less intimate division and mixture of the parts. The reason of this may be easily deduced from the consideration, that nitre does not detonate until in contact with inflammable matter; whence the whole detonation will be more speedy, the more numerous the surfaces of contact. The same cause demands, that the ingredients should be very pure, because the mixture of foreign matter not only diminishes the quantity of effective ingredients which it represents, but likewise prevents the contacts by its interposition. The nitre of the third boiling is usally chosen for making gunpowder, and the charcoal of light woods is preferred to that of those which are heavier, most probably because this last, being harder, is less pulverable. The requisite pounding of the materials is performed in the large way by a mill, in which wooden mortars are disposed in rows, and in each of which a pestle is moved by the arbor of a water-wheel; it is necessary to moisten the mixture from time to time with water, which serves to prevent its being dissipated in the pulverulent form, and likewise obviates the danger of explosion from the heat occasioned by the blows. Twelve hours' pounding is in general required to complete the mixture; and when this is done, the gunpowder is in fact made, and only requires to be dried to render it fit for use. The granulation of gunpowder is performed by placing the mass, while in the form of a stiff paste, in a wire sieve, covering it with a board, and agitating the whole; by this means it is cut into small grains or parts, which, when of a requisite dryness, may be rendered smooth or glossy by rolling them in a cylindrical vessel or cask. Gunpowder in this form takes fire more speedily than if it be afterwards reduced to powder, as may be easily accounted for from the circumstance that the inflammation is more speedily propagated through the interstices of the grains. But the process of granulation does itself, in all probability, weaken the gunpowder, in the same manner as it is weakened by suffering it to become damp; for, in this last case, the nitre, which is the only soluble ingredient, suffers a partial solution in the water, and a separation in crystals of greater or less magnitude; and accordingly the surfaces of contact are rendered less numerous. Berthollet found that the elastic product, afforded by the detonation of gunpowder, consisted of two parts nitrogen gas, and one carbonic acid gas. The sudden extrication and expansion of these airs are the cause of the effects of gunpowder.

GYPSUM. This genus contains two species, the prismatic, and the axifrangible.

I.—Primitive gypsum, or anhydrite. Muriacit. Of this there are five sub-species.

1. Sparry anhydrite.—(See *Cube-Spar.*)

2. Scaly anhydrite. Its constituents are, lime 41·75, sulphuric acid 55, mur. of soda 1·0.

3. Fibrous anhydrite. Colours, red, blue, and grey.

4. Convoluted anhydrite. Its constituents are, 42 lime, 56·5 sulphuric acid, 0·25 muriate of soda.

5. Compact anhydrite. Colour grey, sometimes with spotted delineations. Hardness and constituents as in the preceding. Sp. gr. 2·95

II.—Axifrangible gypsum. This species contains six sub-species.

1. Sparry gypsum, or selenite. Colours grey, white, and yellow, with

occasional iridescence. Its constituents are, 33·9 lime, 43·9 sulphuric acid, 21 water, and 2·1 loss: Bucholz.

2. Foliated granular gypsum. Colours, white, grey, and red; sometimes in spotted or striped delineations. Its constituents are, 32 lime, 30 sulphuric acid, and 38 water, according to Kirwan. The foliated and compact gypsum, when pure and capable of receiving a polish, are termed alabaster by artists, who fashion them into statues and vases. The coarser kinds are used in agriculture, and are converted by calcination into stucco.

3. Compact gypsum. Its constituents are, 34 lime, 48 sulphuric acid, 18 water.

4. Fibrous gypsum. Colours, white, grey, and red. Soft, sectile, and easily frangible. Its constituents are, 33 lime, 44·13 sulphuric acid, 21 water.

5. Scaly foliated gypsum. Colour, white. It occurs along with selenite, at Montmartre, near Paris.

6. Earthy gypsum. Colour, yellowish white. Composed of fine scaly or dusty particles.

Gypsum has probably been formed by the decomposition of iron pyrites, which supplied the sulphuric acid that afterwards united with the subjacent lime. As a confirmation of this, it may be observed, that the marle and sand over gypsum, in many parts of England, contain a large quantity of red oxide of iron. Gypsum is distinguished from lime by its softness: it does not effervesce with any acid, being already saturated with the sulphuric. In some instances native sulphur is found intermixed with gypsum: in these cases, probably, the sulphuric acid has been decomposed by the presence of animal or vegetable matter during the decomposition of pyrites. Gypsum has been occasionally discovered in primary and transition mountains: it belongs more peculiarly to secondary stratified rocks, but may be formed in all situations where lime and sulphuric acid exist near to each other. Though gypsum rarely contains shells, bones are sometimes found in it: hence it has been supposed, that sulphuric acid destroyed the traces of organization in the former, which consist of lime and carbonic acid, but acted with less force on bones, which contain phosphoric acid. The beds of gypsum at Chellaston, in the south of Derbyshire, are situated near the vale of Trent, in hills of low elevation, which may be considered as forming the northern boundary of the vale. The gypsum beds on the other side of the vale are in hills, which form the southern boundary near the junction of the rivers Soar and Trent. The gypsum is covered by marle and gravel containing numerous organic impressions, among which I collected belemnites, graphites, joints of the pentacrinite, and bivalve shells, which appear compressed, and one specimen of a numelite. The principal beds are of considerable thickness; the stone is compact, and where it is not discoloured by an intermixture of red marle, or by stripes of greenish marle, it is white and translucent. Thin strata of beautiful white fibrous gypsum occur in marle, at Clifton, on the south side of the Trent near Nottingham. The geological situation of the Derbyshire gypsum may be represented as situated in the upper secondary strata, separated from the mountain lime by intervening coal districts on one side, and from the stratified magnesian lime by sand-stone on the other side.

H.

HAIR. From numerous experiments, M. Vauquelin infers, that black hair is formed of nine different substances, namely: 1. An animal matter, which constitutes the greater part. 2. A white concrete oil in small quantity. 3. Another oil of a greyish green colour, more abundant than the former. 4. Iron, the state of which in the hair is uncertain. 5. A few particles of oxide of manganese. 6. Phosphate of lime. 7. Carbonate of lime in very small quantity. 8. Silex, in a conspicuous quantity. 9. Lastly, a considerable quantity of sulphur.—The same experiments shew, that red hair differs from black only in containing a red oil instead of a blackish green oil; and that white hair differs from both these only in the oil being nearly colourless, and in containing phosphate of magnesia, which is not found in them.

HÆMATITES, an ore of iron.

HARMOTOME, the same as Cross-stone.

HARTSHORN (Spirit of). Liquid ammonia, which is often made from the horns of animals, is commonly so called.

HAUYNE, a mineral, consisting of 30 silica, 15 alumina, 13·5 lime, 12 sulphuric acid, 11 potash, 1 iron, and 17·5 loss. It is found imbedded in the rocks of Albano and Frescati.

HEAVY SPAR. This spar is divided by Professor Jameson into four species: the two first he denominates rhomboidal baryte, or witherite, and prismatic baryte; the rhomboidal being carbonate of barytes, and the prismatic sulphate of barytes, with some additional substances; the other two species are called diprismatic baryte, or strontianite, and axifrangible baryte, or celestine; the one being the carbonate, the other the sulphate of strontiles. This mineral is remarkable for its specific gravity, the barytes being from 4·1 to 4·6, and the strontiles from 3·7 to 3·9.

HEAT. By this word is usually understood, in common language, the sensation felt from bodies of a high temperature; but in chemistry it is employed to express the cause of that sensation. To avoid ambiguity, for the latter meaning the word caloric is employed.—See *Caloric*.

HELIOTROPE, a species of rhomboidal quartz, consisting of silica 84, alumina 7·5, and iron 5.

HELIOTROPIUM, Turnsole, a plant which yields a valuable blue colour, much used both by the dyer and the experimental chemist, called archil or litmus.—See *Archil*.

HELLEBORE, a powerful vegetable, formerly much used in medicine, but now little employed, on account of its poisonous qualities: there are two kinds, the white hellebore and the black hellebore.

HEMATIN, the colouring matter of the hematoxylon campechianum, or logwood, much used in dyeing.

HEPAR SULPHURIS, or Liver of Sulphur, a name given from the brown colour to combinations of sulphur with alkalies and earths.

HEPATIC AIR, sulphuretted hydrogen gas.

HEPATITE, is a variety of lamellar barytes, containing a portion of sulphur, on account of which when rubbed it gives out a foetid smell.

HOLMITE, a mineral, specific gravity 3·6, consisting of 27 lime, 21 carbonic acid, 6¼ alumena, 6¼ silica, 29 oxide of iron, and 10 water.

HOMBERG'S PHOSPHORUS, is ignited muriate of lime.

HONE, a slate used in whetting edged tools.

HONEY, believed to consist of sugar, an acid, and mucilage.

HONEY-STONE, Mellite, a mineral, from which the mellitic acid is obtained. It consists of 46 mellitic acid, 16 alumina, and 38 water.

HOOFS of animals consist of coagulated albumen.

HORN, an animal substance, consisting of coagulated albumen with a little gelatin. The horns of the buck are of a nature between horn and bone.

HORN SILVER, a combination of chloric acid and silver.

HORNBLENDE. This mineral forms a constituent part of many rocks, and appears to connect the primary with those of a volcanic origin. It is of a black or dark green colour; it is heavier, but less hard than quartz or felspar; it may be scratched with a knife, and the colour of the scratch is light green; it yields a better smell when breathed upon, and melts easily into a black glass. Hornblende forms entire mountains or beds in mountains, and is very commonly met with in granular pieces, as an ingredient in compound rocks; when it becomes more abundantly and minutely disseminated in them, it forms what are called trap and basaltic rocks, whose origin has greatly divided the opinion of geologists. Hornblende, and the rocks to which it is allied, contains as under:

	Hornblende.	Basalt	Obsedian.	Lava.
Silex -	42	44	72	49
Alumine -	8	16	12	35
Magnesia -	16	2		
Lime -	9	9	sometimes with magnesia.	4
Oxyd of iron	23	20	2	12
Soda -	—	4	6 with potass.	
Manganese	1			
Water & loss	1	5	8	
	[illegible]	[illegible]	[illegible]	[illegible]

There are three species: common hornblende, hornblende slate, and basaltic hornblende.

HORNSTONE is divided into three species:—1. Splintery hornstone; it consists of 98·25 silica, 0·75 alumina, 0·50 oxide of iron, and 0·50 water. The pedestal of the statue of Gustavus III. is formed of this stone.—2. Conchoidal hornstone.—3. Woodstone, which occurs in pieces in the shape of trunks, branches, and roots.

HORSERADISH. This root in distillation yields an acrid oil.

HOSPITAL ULCER, a peculiar morbid secretion.

HUMITE, a mineral, of a reddish brown colour, found at Somma, the mount adjacent to Mount Vesuvius. It was so named in honour of Sir Abraham Hume.

HYACINTH, a species of zircon. It contains, according to Klaproth,

Zircon - -	70·00
Silica - -	25·00
Oxide of iron	0·50
Loss - - -	4·50
	100·00

The colours are red, brown, and, more rarely, yellow, green, and grey. The darker varieties lose their colour by heat, and are made, by artists, to have a resemblance to diamonds.

HYALITE, a mineral of a yellow and greyish white. It consists of 92 silica, and 6·33 water. It is cut into ring-stones.

HYDRAGYLITE, the same as Wavellite.

HYDRATES, compounds, in definite proportions, of metallic oxides with water.

HYDRIODATES, salts of the hydrodic acid, with certain bases.

HYDRODIC acid consists of iodine and hydrogen; which, when in a gaseous state, unite in equal volumes, without change of bulk. Its composition, by weight, is 8·61 iodine, and 0·0694 hydrogen. An aqueous hydriodic acid is obtained by passing sulphuretted hydrogen gas through a mixture of water and iodine, in a Woulfe's bottle. Salts have been formed of this acid, with potass, soda, barytes, lime, strontites, ammonia, magnesia, and zinc.

HYDROCHLORIC acid is muriatic acid gas, which is a compound chlorine and hydrogen.

HYDROCYANIC ACID.—See *Prussic Acid*.

HYDROGEN GAS. Hydrogen, by itself, is always in the form of gas. It is the lightest substance in nature, at present known, being 14·4 less dense than common air, 16 times less dense than oxygen, and 14 times less dense than azote. It was first discovered in 1776 by Mr. Cavendish. Hydrogen gas is a constituent of water, which may be formed by exploding oxygen and hydrogen together. Hydrogen gas can be obtained only from water. The following mode will be found convenient for that purpose: Into a tubulated retort put an ounce and a half of iron filings, and pour over them the same quantity of sulphuric acid, diluted with eight ounces of water. Now place the beak of the retort directly under one of the perforations of the pneumatic shelf, which is to have a jar or bottle filled with water inverted immediately over it. The gas will be extricated in the retort, and from its levity will ascend in the jar, bubbling and displacing the water. In this way successive jars may be filled. Where it is not convenient to use the pneumatic trough, hydrogen gas may be procured, with much economy, by using a wash-hand-basin, and other simple apparatus. In this experiment, the water, in combination with the acid, oxidises the iron filings, and is thereby deprived of its oxygen; for in order that the metal may be dissolved by the acid, it must be first oxidised, and for that purpose it rapidly abstracts the oxygen from the water, by which means the water is decomposed, and the hydrogen is set free.

Hydrogen Gas may be obtained by the Decomposition of Water by Red-hot Iron.

Another method of procuring hydrogen gas is, by passing the steam or vapour of water through a red-hot iron tube, as follows:—Pass a gun-barrel, (the breech of which has been cut off) through a furnace, and apply the beak of a retort which is half filled with water to one end of it. Place the retort upon a stand, and apply a lamp under it. Now affix to the other end of the tube or gun-barrel, a bent tube connected with a receiver. The water passing in the state of steam over the internal surface of the red-hot barrel, will be decomposed; its oxygen uni-

ting with the iron forming oxide of iron, whilst the hydrogen is set free. The same results will take place when an earthen tube containing iron filings is used. If the filings which have been thus oxidised be afterwards weighed, they will be found to have increased one-third more than their original weight. By this experiment it is obvious that hydrogen constitutes one part of water; and if the oxidised filings be submitted to great heat, they will give out the other constituent of water, viz. the oxygen, which they received by the decomposition above illustrated. Hence, by this analysis water is proved to be a compound body; and to banish all doubt of the really wonderful fact, that these two gases coalesce to form this salubrious and universally supplied fluid, synthesis has been had recourse to; that is, the two gases have been burnt together, or rather, the hydrogen has entered into, and continued in a state of active combustion, by a continued supply of oxygen, and the result has been the formation of water. Red-hot charcoal likewise has the power of decomposing water; and there can be little doubt, that when water, in quantities so small as those emitted from a common engine-pipe, are thrown upon burning houses, the beams, &c., which are suffering a rapid conversion into charcoal, decompose it as fast as it is thrown upon them; thus setting immense volumes of hydrogen free, which of course take fire as soon as they are evolved, and add greatly to the combustion.

In very accurate experiments, the gas must be received in jars, over mercury, and exposed to the action of dry muriate of lime, at a low temperature. When it stands over water, its specific gravity acquires an increase of one-seventh. From the great rarity of this gas, it is used to fill balloons; but it is not necessary to have pure hydrogen gas for that purpose; and carburetted hydrogen, such as is used to light the streets, will do sufficiently well; and such was used for the balloon sent up on the day of the coronation of King George IV. This gas is colourless, very combustible, and if pure, burns with a yellowish white flame. It extinguishes animal life.

Combined with

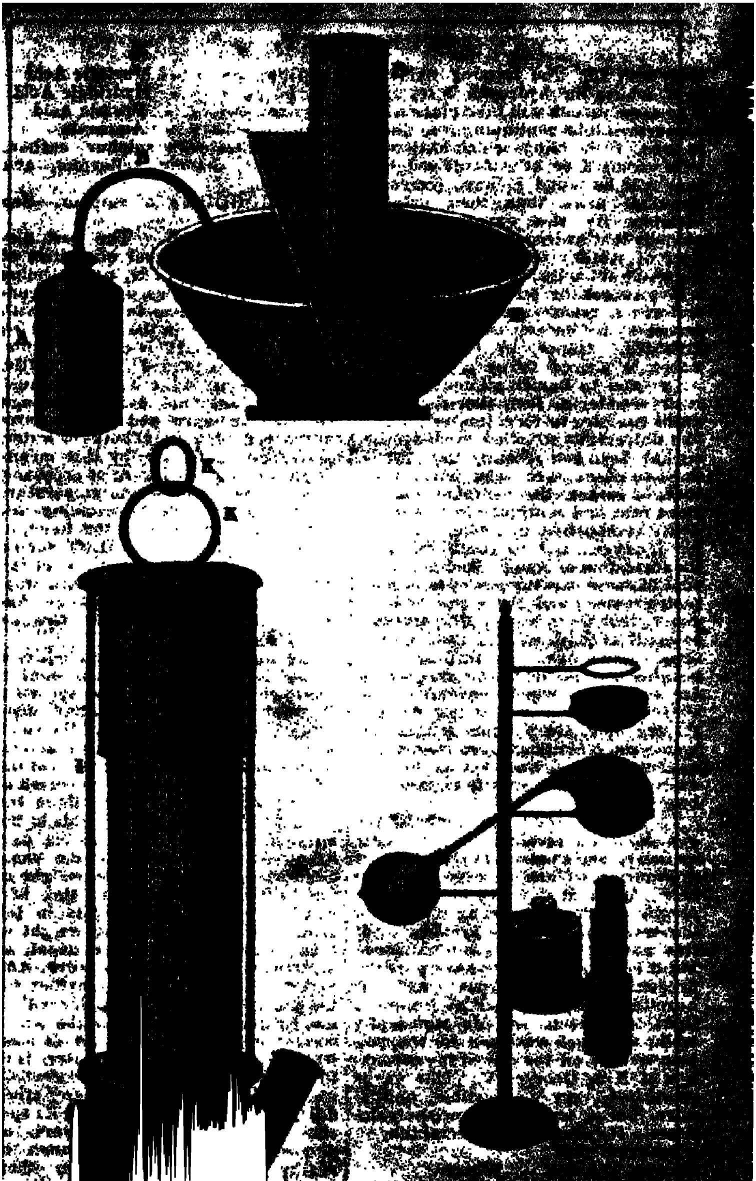
Oxygen, it forms	-	Water
Chlorine	- - -	Muriatic Acid
Iodine	- - - -	Hydriodic Acid
Prussine	- - - -	Prussic Acid
Azote	- - - - -	Ammonia

It also unites with sulphur, carbon, phosphorus, arsenic, sellurium, and potassium.

HYDROGURET of sulphur.—See *Sulphur*.

HYDROMETER. The best method of weighing equal quantities of corrosive volatile fluids, to determine their specific gravities, appears to consist in enclosing them in a bottle with a conical stopper, in the side of which stopper a fine mark is cut with a file. The fluid being poured into the bottle, it is easy to put in the stopper, because the redundant fluid escapes through the notch, or mark, and may be carefully wiped off. Equal bulks of water, and other fluids, are by this means weighed to a great degree of accuracy, care being taken to keep the temperature as equal as possible, by avoiding any contact of the bottle with the hand, or otherwise. The bottle itself shews, with much precision, by a rise or fall of the liquid in the notch of the stopper, whether any such change has taken place.—*See Specific Gravity* and *Alcohol*.

The hydrometer of Fahrenheit consists of a hollow ball, with a counterpoise below, and a very slender stem above, terminating in a small dish. The middle, or half length of the stem, is distinguished by a fine line across. In this instrument every division of the stem is rejected, and it is immersed in all experiments to the middle of the stem, by placing proper weights in the little dish above. Then, as the part immersed is constantly of the same magnitude, and the whole weight of the hydrometer is known, this last weight added to the weights in the dish, will be equal to the weight of fluid displaced by the instrument, as all writers on hydrostatics prove. And accordingly, the specific gravities for the common form of the tables will be had by the proportion:—As the whole weight of the hydrometer and its load, when adjusted in distilled water, is to the number 1000, &c. so is the whole weight, when adjusted in any other fluid, to the number expressing its specific gravity. The hydrometers, or *pese-liqueurs* of Baume, though in reality comparable with each other



are subject in part to the defect, that their results, having no independent numerical measure, require explanation to those who do not know the instruments.

Baume's Hydrometer for Spirits
Temperature, 55 Fahrenheit, or 10 Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.
10 —	1·000	26 —	·892
11	·990	27	·886
12	·985	28	·880
13	·977	29	·874
14	·970	30	·868
15	·963	31	·862
16	·955	32	·857
17	·949	33	·852
18	·942	34	·847
19	·935	35	·842
20	·928	36	·837
21	·922	37	·832
22	·915	38	·827
23	·909	39	·822
24	·903	40	·817
25	·897		

With regard to the hydrometer for salts, the learned author of the first part of the Encyclopædia, Guyton de Morveau, who by no means considers this an accurate instrument, affirms, that the sixty-sixth degree corresponds nearly with a specific gravity of 1·848; and as this number lies near the extreme of the scale, I shall use it to deduce the rest.

Baume's Hydrometer for Salts.
Temperature, 55 Fahrenheit, or 10 Reaumur.

Deg.	Sp. Grav.	Deg.	Sp. Grav.
0 —	1·000	39 —	1.373
3	1·020	42	1·414
6	1·040	45	1·455
9	1·064	48	1·500
12	1·089	51	1·547
15	1·114	54	1·594
18	1·140	57	1·659
21	1·170	60	1·717
24	1·200	63	1·779
27	1·230	66	1·848
30	1·261	69	1·920
33	1·295	72	2·000
36	1·333		

It may not be amiss to add, however, that in the Philosophical Magazine, Mr. Bingley, the assay-master of the mint, has given the following numbers as the specific gravity of nitric acid, found to answer to the degrees of an areometer of Baume by actual trial; temperature about 60 deg. Fahr. But his appears to have been a different instrument, as it was graduated only from 0 to 50 deg.

Deg.	Sp. Grav.	Deg.	Sp. Grav
18 —	1.160	36 —	1.333
20	1.167	37	1.342
26	1.216	38	1.350
28	1.233	39	1.358
29	1.150	40	1.367
30	1.267	41	1.383
31	1.275	42	1.400
32	1.283	43	1.416
34	1.300	45	1.435
35	1.312		

There are a variety of hydrometers used for determining the strength of ardent spirit. See *Alcohol* and *Distillation*.

HYDROPHANE. This mineral is a kind of opal, and has the remarkable property that when immersed in water it will appear transparent. It has been called oculus mundi. Very clear and pure water ought to be used, or otherwise the pores will be filled with earthy particles, and it will cease to be transparent.

HYDROPHOSPHOROUS ACID, is obtained from phosphuret of barytes, by pouring water upon it, and waiting till the phosphuretted hydrogen be disengaged. To this sulphuric acid is to be added till the barytes be precipitated and the supernatant liquor is hydrophosphorous acid.

HYDROSULPHURETS. Sulphuretted hydrogen combined with salifiable bases.

HYDROTHIONIC ACID. Sulphuretted hydrogen. It is called hydrosulphuric acid by M. Gay Lussac, from its possessing acid properties.

HYDROSULPHURIC ACID and HYDROSULPHUROUS ACID. See *Sulphuric* and *Sulphurous Acid*.

HYGROMETER. It is very frequently necessary in experiments in chemistry and natural philosophy, to know exactly the quantity of water which exists at the time in a state of vapour in the atmospheric air or in a gas. If there were any certainty of this quantity being carried as far as saturation, it would then be very easy to estimate it, since the temperature being given, its elastic force might be calculated by the theory of Mr. Dalton, and its weight by the experiments of M. Gay Lussac. But when we have no knowledge of the state of the atmosphere or of the gas made use of, it is necessary to seek other means to

ascertain the quantity of water which is found in vapour. Such is the object of that part of philosophy which is called hygrometry; the greater or less quantity of vapour which the gases contain, constitutes what is called hygrometrical state, and the instruments fitted for ascertaining this state, are called hygrometers or hygroscopes. Almost all hygrometers are founded on the variation of the volume which organic substances experience by the introduction or abstraction of vapours. Every one knows the difference of elasticity which exists between a piece of wet parchment and a piece of dry parchment. The strings of catgut employed in musical instruments change their elasticity and tone, according to the humidity and tone introduced into them. They untwist and become shorter, because they augment their thickness. The beards of many plants experience this effect in a very remarkable manner, so that if one of them be fixed perpendicular to a piece of pasteboard for its base, and then be pasted perpendicularly to its other end, a small piece of paper perpendicular to its length, the twisting which this beard experiences by the variations of humidity and dryness, is sufficiently great to mark by the needle on paper very great arcs. It is this principle applied to catgut that there are made those little figures which shew by their motions, dry weather or rain. Amongst the substances possessed of these hygrometrical properties, there are none more sensible or more constant in their properties than hair dipped in a solution of potass, which clears them of the grease with which they are covered in their natural state. The hair after this preparation, shortens by dryness, and lengthens by moisture, which does not prevent it also from being lengthened by the heat and shortened by the cold, but in a proportion much less. Saussure made use of hair thus prepared in the construction of an hygrometer which bore his name, and which enabled him to make researches of this sort with an exactness before unknown. The upper end of the hair is fixed by a peg which keeps hold of it. The lower end is fastened in the same manner to the circumference of a very moveable pulley, which is drawn up by the hair, and down by a little weight. When the hair is shortened it makes the pulley turn in one direction; and if it be lengthened the weight makes it turn in the opposite direction. The pulley, as it turns round, moves a long needle, which, by its motions on the arc of a graduated circle, indicates the shortening or lengthening which the hair undergoes in consequence of the variations of the surrounding air. If this hygrometer be shut up in a *manometer* filled with air, or with any gas, of which the sides are wetted with water, the needle will soon be seen to move upon the division, so as to announce the lengthening of the hair; at last it stops at a certain boundary; then, if this hygrometer be removed to another manometer where the air within it has been for some days enclosed along with some drying substances, the needle is soon seen to go backwards, as naturally arises from the shortening of the hair; after which, it again stops. Whatever be the temperature at which the experience is made, provided the manometer be saturated by watery vapour, or be completely deprived of it by desiccation, these points at which the needle stops are always the same. Saussure calls one of them the term of extreme dryness, and marks it by 0; he denominates the other the term of extreme humidity, and marks it by 100; then dividing the arc, which they comprehend, into 100 equal parts, each of these parts furnishes him so many intermediate degrees of humidity. Mr. Leslie, by a slight modification of his differential thermometer, makes it serve the purpose of an hygrometer; for if one of the balls be covered with silk, and then moistened with water, the rate of evaporation will be shewn by the degree of cold produced, as indicated by the descent of the liquid in the opposite leg of the instrument The drier the air, the quicker will be the evaporation, and the greater the effect in moving the liquid within the instrument. An ingenious hygrometer was constructed by Mr. Wilson of Dublin. It consists of the urinary bladder of a rat or other small animal, into which a thermometer tube is inserted, the bladder being afterwards filled with mercury and tied firmly over the tube with a silk thread. The

point of extreme moisture is taken by immersing the bladder in water of the temperature of 60 Fahrenheit, and that of extreme dryness by enclosing the bulb in air dried by contact with concentrated sulphuric acid. The interval is divided into 100 equal parts, 0 being placed at the point of extreme dryness, and 100 at that of extreme moisture.

HYPERSTENE. Labrador Schillerspar. It has a beautiful copper red colour when cut and polished into ringstones and brooches.

I.

JADE. See *Nephrite.*

JALAP, a root which is used in medicine as a purgative. According to Dr. Henry, three kinds of jalap yielded as follows:

	Jalap leger.	Jalap sain.	Jalap pique.
Resin,	60	48	72
Extract,	75	140	125
Starch,	95	102	103
Woody fibre,	270	210	200
	500	500	500

JARGON, the same as Zircon. Considering the numerous barbarous names introduced by the Germans and their imitators into mineralogy, it is not unsuitable that such a term as this should have been one.

JASPER. This beautiful mineral is classed by Professor Jameson as a species of rhomboidal quartz. There are five kinds: Egyptian jasper; striped jasper, porcelain jasper, common jasper, and agate jasper. The jaspers have bright and beautiful colours, and may be cut into ornaments, and bear a fine polish.

ICE. See *Caloric* and *Water.*

ICELAND SPAR. See *Calcareous Spar.*

ICE-SPAR. A kind of felspar.

ICHTHYOPHTHALMITE, or fish-eye. See *Apophyllite.*

ICHTHYOCOLLA. Fish glue or Isinglass.

IDOCRASE. See *Vesuvian.*

JELLY made of currants and other fruits, consists of mucilage and acid.

JENITE. See *Lievrite.*

JET. See *Coal.*

IGNIS FATUUS. A luminous appearance or flame, frequently seen in the night in different country places, and called in England Jack-with-a-lantern, or Will-with-the-wisp. It seems to be mostly occasioned by the extrication of phosphorus from rotting leaves and other vegetable matters. It is probable that the motionless ignes fatui of Italy which are seen nightly on the same spot, are produced by the slow combustion of sulphur, emitted through clefts and apertures in the soil of that volcanic country.

INCINERATION. The combustion of vegetable or animal substances, for the purpose of obtaining their ashes or fixed residue.

INCOMBUSTIBLE. In the article on combustion we have shown that there are substances which will not undergo that action to whatever heat they may be exposed. There are many substances of vegetable origin, of common domestic use, which it would be of the utmost importance to render less liable to be set on fire, if they could not be rendered incombustible altogether. If muslins, and other cotton goods, be dipped in a weak solution of potass, they will be less likely to burn; but the objection is, that by the attraction of moisture from the atmosphere, they would be less agreeable. It has also been found, that solutions of muriate, sulphate, phosphate, and borate of ammonia, with borax, render cloth incombustible. Acidulous phosphate of lime has the same effect. Linen, muslin, wood, or paper, dipped in a solution of this salt, of the specific gravity of 1·26 to 1·30, are completely incombustible, and may be charred by intense heat, but will not burn. Several experiments were made at Venice in 1807, by a Monsieur Gonzatti, with a liquor, which being thrown in a small quantity on any combustible article on fire, has immediately extinguished it. A few drops only, being thrown on a quantity of resin and oil, which was burning, the fire was immediately extinguished; and it was said, that a layer of this composition being spread upon any wood work, it was entirely safe from combustion. The inventor would not make known the preparation of his composition, but it was, very probably, a solution of alum, potass, and vitriol. A com-

mittee, appointed by the Board of Ordnance, inspected a machine invented by captain Manby, for the extinction of fire by an anti-phlogistic fluid, at the committee room, Woolwich barracks. He showed that it could be instantly applied (being kept ready loaded) to fires which were so situated that a common fire-engine would be of no service: for instance, in the back apartments of a house, or under the deck of a vessel. He explained the nature of the fluid which the machine was charged with; it consists of lime with potash, and a certain quantity of water, and might be made in two minutes; on ship-board a cask of it might always be in readiness, besides the machine being charged with it. To exhibit the extraordinary effects of the anti-phlogistic ingredients, he immersed in it a quantity of hemp, canvas, and deal wood, which are the most combustible materials used in a dock yard; he also immersed the same materials in common water, and applied a certain heat to each; those which had been dipped in the anti-phlogistic fluid would not burn, and those dipped in common water blazed immediately. He also sprinkled some hemp with the fluid, and some with common water, which had the same effect: that sprinkled with water burned, and the other did not. Analogous to this mode of preventing combustion, is that used by fire-eaters, and other miracle-mongers of the same description. M. Sementina, a chemist of Naples, having most ingeniously detected the mode used by a Spanish exhibitor of this sort, has given to the world a very interesting detail of these exploits, with his own discoveries on the subject. We present the reader with this narrative in the professor's own words, as reported in the Moniteur Universelle, for November 8, 1809.

"The Incombustible Man.

"Signior Lionetto commenced his tricks by putting on his head a slender ring, or hoop, of red-hot iron, and which to all appearance made no impression on his hair; but when the hoop of iron came in contact with the hair, a thick vapour was seen to ascend. He then took another piece of red-hot iron and passed it over the whole length of his arm and leg, and he applied for a considerable time another piece of hot iron to his heel and his foot, from whence also ascended such a thick and disagreeable vapour, that my eyes and lungs were much affected thereby. He also held between his teeth a piece of iron, which, although not red, was sufficiently hot to burn. He had given out, that he would drink half a glass of boiling oil; but I did not find that he could take any such dose, and I only saw him take within his mouth about the quarter of a spoonful. It was also reported, that he had washed his face and hands in boiling lead; but he contented himself before me, with quickly dipping the ends of his fingers in the melted metal, and putting a small quantity thereof on his tongue, after which he applied a piece of hot iron to his tongue, seemingly without any inconvenience; while repeating this experiment several times, I clearly perceived his tongue to be covered with the appearance of a greyish skin, similar to that of a person having a fever.

"Another of his experiments was that of thrusting a thick golden pin through the skin of his arm, without feeling the least pain. In this proof of his insensibility, I observed, that the pin went through his skin with great difficulty, and required as much force as if it had been applied to tanned leather.

"Instead, therefore, of uselessly wasting time in simple conjectures, I resolved to adopt the best experimental arts, trying on myself the action of all the means proper to benumb the cutaneous nerves, and to clothe the skin with a substance which was a non-conductor of caloric. Few substances belonging to chemical compositions appeared to me proper for this purpose. The sharp sensation which was excited by the vapour, disengaged by the contact of fire with the incombustible membrane, and the chemical reason, induced me first to have recourse to acid substances, and to some of the acidulous salts.

"These essays with the acidulous salts, and alum in particular, were only the rudiments of a knowledge of the phenomenon, the examination of which was still incomplete. An accidental combination afterwards induced me to undertake a new series of experiments by which I might be

enabled to give a more clear explanation of all the more difficult operations executed by this reported incombustible man. Wishing to examine if washing the almost incombustible part (rendered so by the action of alum), would make it lose the quality it had acquired, I rubbed it with hard soap, then washed and dried it with a cloth, and then applied a piece of red-hot iron. I was then much surprised to find, that the skin of that part not only preserved the same insensibility, but was even stronger than at first. I again rubbed the same part with soap, without wiping it with the cloth, and passed over it the red-hot iron, without feeling the least effect of burning, or even of singing the hair. Remembering the crust which I had observed on the fire-eater's tongue, I was determined to rub mine with the same sort of soap, and it fully answered the desired purpose, beginning first with iron slightly heated, and raising the heat gradually until it was red-hot. I made a soft paste of soap, triturated in a mortar, with water saturated by acidulous sulphate of alumine and potass; and spreading this composition on my tongue, the experiment completely succeeded. Still more simple I found the process of first bathing the tongue with sulphureous acid, and afterwards rubbing it often with a piece of soap. The experiment succeeded still better, when after bathing the tongue with this acid, I covered it with a thin stratum of sugar reduced to impalpable powder, and rubbed it afterwards with the soap in the same manner. The sugar, in this case, like a mordant, made a greater quantity of soap adhere to the tongue. Of all the known substances, soap is that which best merits the name of restrainer of caloric.

"From these experiments I proceeded to that with the boiling oil, putting at first a very small drop, considerably heated, on my tongue, and afterwards increasing the quantity and heat. This experiment was also satisfactory: the oil put on the tongue thus prepared, made a hissing noise, similar to that made by red-hot iron when brought in contact with a humid body; after the hissing, the oil ceased to be hot, and was easily swallowed. From all these facts, I am led to account as follows for the phenomena exhibited by Lionetto:—

"1. The hair over which he passed the hot iron had been first bathed with a solution of alum; and hence, the origin of the vapour which arose from his hair.

"2. The hot iron with which he rubbed his legs and arms produced no bad effects, from a similar preparation being used.

"3. The same reason will also apply to the experiment with his foot, although the contact with the iron was much longer; but it is well known that the foot is the most callous part of the human body.

"4. With respect to the boiling oil, we will minutely follow Lionetto's experiments. He took the oil from the fire, and to convince the audience of its high temperature, he threw therein a quantity of lead, which melted; but it is only reasonable to conclude, that this was a mere stratagem to cool the oil. Of the oil thus cooled, he took barely a quarter of a spoonful, and this he let dexterously fall on his tongue only; which was perhaps prepared in such a manner, that it immediately cooled the oil, which was then swallowed scarcely tepid.

"5. The experiment of the melted lead, in which he occasionally dipped his fingers, and put a very small quantity, not in his mouth, but on his tongue, can easily be accounted for in the same way."

INCOMBUSTIBLE CLOTH. See *Asbestus*.

INDIGO. A blue colouring matter extracted from a plant called Anil, or the Indigo plant. In the preparation of this drug, the herb is put into a vat or cistern, called the steeping trough, and there covered with water. The matter begins to ferment sooner or later, according to the warmth of the weather and the maturity of the plant; sometimes in six or eight hours, and sometimes in not less than twenty. The liquor grows hot, throws up a plentiful froth, thickens by degrees, and acquires a blue colour inclining to violet. At this time, without touching the herb, the liquor impregnated with its tincture, is let out by cocks in the bottom into another vat placed for that purpose, so as to be commanded by the first. In the second

vat, called the beating vat, the liquor is strongly and incessantly beaten with a kind of buckets fastened to poles, till the colouring matter is united into a body. As soon as it is judged, from the blue colour of the liquid, that the beating is sufficient, it is left at rest for two hours; after which the clear liquor is drawn off by cocks in the side of the vat, and the blue part is discharged by another cock into a third vat, where it is suffered to settle for some time longer; then conveyed in a half fluid state into bags of cloth, to strain off more of its moisture; and lastly, exposed to the air in the shade in shallow wooden boxes, till it is thoroughly dry. Bergman examined this drug. He found, that one-ninth part of the indigo was taken up by boiling it in water. The parts dissolved were partly mucilaginous, partly astringent, and partly saponaceous. The solution of alum, and of sulphate of iron as well as of copper, precipitate the astringent portion. Bergman mixed one part of well pulverized indigo with eight parts of colourless sulphuric acid, of the specific gravity of 1.900, in a glass-vessel slightly closed. The acid very quickly acted upon the indigo, and excited much heat. After a digestion of twenty-four hours, the solution was effected; but the mixture was opaque and black. If the sulphuric acid be first diluted in the water, it attacks only the earthy principle which is mixed with the indigo, and some of the mucilaginous parts. The fixed alkalis saturated with carbonic acid, separate a very fine blue powder from the solution of indigo, which is deposited very slowly. The concentrated nitric acid attacks indigo with so much activity, as to set it on fire. The muriatic acid by digestion, and even boiling upon indigo, takes up only the earthy matter, the iron, and a little of the extractive matter, which gives it a brown colour, but in no respect attacks the blue colour. Pure or caustic fixed alkali dissolves some matters foreign to the colouring matter of the indigo, but acts very little on the colouring particles. Pure volatile alkali has nearly the same effect. Precipitated indigo is speedily dissolved in the cold in the alkalis, whether fixed or volatile, if pure or caustic. The blue colour is gradually changed to a green, and at last destroyed. Bergman concludes, from his analysis, that 100 parts of good indigo contain of mucilaginous matter separable by water 12, resinous matter soluble in alcohol 6, earthy matter taken up by the acetic acid, which does not attack the iron, here, in the state of oxide 22, oxide of iron taken up by the muriatic acid 13. There remained 47 parts, which are the colouring matter, nearly in a state of purity, and afforded by distillation, carbonic acid 2, alkaline liquor 8, empyreumatic oil 9, coal 23. The solubility of indigo in alkalis, appears to be produced by the abstraction of part of the oxygen it had absorbed. This appears to be well established from the experiment of Bergman, wherein equal weights of sulphate of iron and indigo, and double the weight of lime, are mixed together in water, and produce a solution of the indigo in the lime-water. But if the iron of the sulphate be previously oxidized to a higher degree, by boiling it in much water for several hours, and subsequent evaporation, the solution will not be effected, because the precipitated iron is no longer disposed to absorb oxygen. Or again, if indigo be added to a solution of caustic fixed alkali, and orpiment be added (which consists of arsenic and sulphur), the indigo is soon dissolved, and takes a green colour. If the arsenic corresponding with the orpiment be only added, the bath will never be fit for the dyer; but if the quantity of sulphur it ought to contain, be added, the appearances of solution will speedily be had. It follows, therefore, that indigo contains oxygen in its natural state; that in this state it will not unite with lime or alkalis; but that substances capable of depriving it of part of its oxygen, render it soluble in lime or alkalis; and lastly, that the natural state of the indigo is restored by the contact of oxygen, which it absorbs. In this last way it is, that the blue dye is effected. The piece comes out of the vat of the same colour as the solution, viz. green; but becomes blue by exposure to the air. The alkali, or lime, is carried off by the washing, and the indigo remains combined with the stuff, by this means dyed. According to Dr. Thomson, indigo consists of

Oxygen,	46.154
Carbon,	40.384
Azote	13.462
	100.000

It is remarkable there is no hydrogen in this vegetable substance. Blue indigo approaches to the nature of a solifiable base; but deoxidized indigo seems to possess acid powers by being capable of uniting with akalis and alkaline earth.

INDURATED MUD. The American volcanoes discharge torrents of mud which seem to be strongly impregnated with iron. It has been said that similar torrents have issued from Etna and Vesuvius, but it is supposed that the appearances have arisen from melted snow. The grand volcanoes of Cotopaesi, Tungafunga, and Sangay in South America, eject prodigious quantities of mud, and what is more remarkable, prodigious quantities of fish, so as to infect the air with putrefaction. These fish appear to be little injured, and are the same with those found in the rivulets at the bottom of the volcanoes, being a pimelodes silurus from two to four inches in length. These muddy eruptions become fertile clay, and are very productive. Ferrara gives an interesting account of a muddy eruption at Macaluba in Sicily. Sometimes this phenomenon appears with immense force. The inhabitants of the neighbourhood still remember with terror the eruption of 1777, one of the most violent yet known. On the 29th of September, were first heard dreadful bellowings all around, the whole earth shook to the distance of some miles, and from the midst of the plain, in which was formed a vast gulf, arose to the height of about one hundred feet, an immense column of mud, which at the top, and abandoned by the impulsive force, assumed the form of a large tree. The middle was formed of stones of all kinds and sizes, which darted violently and vertically within the body of the column. This terrible explosion lasted half an hour when it became quiet, but after a few minutes resumed its force, and with these intermittences, continued all the day, but the smoke lasted all the night. During the time of this phenomenon a pungent odour of sulphurated hydrogen gas was felt at a great distance, to the surprise of all the inhabitants, who did not dare to approach this spot on account of the horrible noises. But many came the following day and found that the new great orifice had ejected several streams of liquid chalk (creta) which had covered with an ashy crust of many feet all the surrounding space, filling the cavities and chinks. The hard substances ejected were fragments of calcareous tufo, of crystallized gypsum pebbles, of quartz and iron pyrites, which had lost their lustre and were broken in pieces, and all these substances form the outward circuit at this day. The unpleasant smell of sulphur still continued, and the water which remained in the holes continued hot for many months, while a keen smell of burning issued from the numerous orifices around the great gulf, which was now completely filled. Indurated mud and eruptions of mud are found in the island of Iceland.

INK. Every liquor or pigment used for writing or printing, is distinguished by the name of ink. Common practice knows only black and red. Of black ink there are three principal kinds:—1. Indian ink; 2. Printers' ink; and 3. Writing ink. The Indian ink is used in China for writing with a brush, and for painting upon the soft flexible paper of Chinese manufacture. It is ascertained, as well from experiment as from information, that the cakes of this ink are made of lampblack and size, or animal glue, with the addition of perfumes or other substances not essential to its quality as an ink. The fine soot from the flame of a lamp or candle, received by holding a plate over it, mixed with clean size from shreds of parchment or glove-leather not dyed, will make an ink equal to that imported. Good printers' ink is a black paint, smooth and uniform in its composition, of a firm black colour, and possesses a singular aptitude to adhere to paper thoroughly impregnated with moisture. The consistence and tenacity of the oil in this composition are greatly increased, and its greasiness diminished, by means of fire. Linseed oil or nut oil is made choice of for this use. The nut oil is supposed to be the best, and is accordingly preferred for the black ink, though the darker colour it ac-

quires from the fire renders it less fit for the red. It is said, that the other expressed oils cannot be sufficiently freed from their unctuous quality. Ten or twelve gallons of the oil are set over the fire in an iron pot, capable of holding at least half as much more; for the oil swells up greatly, and its boiling over into the fire would be very dangerous. When it boils it is kept stirring with an iron ladle; and if it do not itself take fire, it is kindled with a piece of flaming paper or wood; for simple boiling, without the actual ascension of the oil, does not communicate a sufficient degree of the drying quality required. The oil is suffered to burn for half an hour or more, and the flame being then extinguished, by covering the vessel close, the boiling is afterwards continued with a gentle heat, till the oil appears of a proper consistence; in which state it is called varnish. It is necessary to have two kinds of this varnish, a thicker and a thinner, from the greater or less boiling, to be occasionally mixed together, as different purposes may require; that which answers well in hot weather being too thick in cold, and large characters not requiring so stiff an ink as small ones. The thickest varnish, when cold, may be drawn into threads like weak glue, by which criterion the workmen judge of the due boiling, small quantities being from time to time taken out and dropped upon a tile for this purpose. It is very viscid and tenacious, like the soft resinous juices, or thick turpentine. Neither water nor alcohol dissolves it; but it readily enough mingles with fresh oil, and unites with mucilages into a mass diffusible in water in an emulsive form. Boiling with caustic alkali produces a soapy compound. It is by washing with hot soap-lees and a brush that printers clean their types. The oil loses from one-tenth to one-eighth of its weight by the boiling into the thick varnish. It is affirmed, that varnish containing either turpentine or litharge, particularly the latter, is more adhesive than other varnish, and presents a greater difficulty in cleaning the types, which soon become clogged. Very old oil requires neither of these additions. New oil can hardly be brought into a proper state for drying, so as not to set off, without the use of turpentine Lampblack is the common material to give the black colour, of which two ounces and a half are sufficient for sixteen ounces of the varnish. Vermillion is a good red. They are ground together on a stone with a muller, in the same manner as oil paints. The ink used by copperplate printers differs in the oil, which is not so much boiled as to acquire the adhesive quality. This would render it less disposed to enter the cavities of the engraving, and more difficult either to be spread or wiped off. The black is likewise of a different kind. Instead of lampblack, or sublimed charcoal, the Frankfort black is used, which is a residual or denser charcoal, said to be made from vine-twigs. This is softer and less gritty than the ivory or other blacks prepared among us, and, no doubt, contains more coal than any animal residue, as all these abound with phosphate of lime. It is said, that lampblack gives always a degree of toughness to the ink, which the Frankfort black does not; but the goodness of the colour seems to be the leading inducement for the use of the latter. A pale or brown black can be much more easily endured in a book than in the impression of an engraving. We have no good explanation of what happens with regard to the chemical effect of boiling and burning upon the oil for printers' use. Common ink for writing is made by adding an infusion or decoction of the nutgall to sulphate of iron, dissolved in water. A very fine black precipitate is thrown down, the speedy subsidence of which is prevented by the addition of a proper quantity of gum arabic. This is usually accounted for by the superior affinity of the gallic acid, which, combining with the iron, takes it from the sulphuric, and falls down. But it appears as if this were not the simple state of the facts; for the sulphuric acid in ink is not so far disengaged as to act speedily upon fresh iron, or give other manifestations of its presence in an uncombined state. According to Deyeux, the iron in ink is partly in the state of a gallate. M. Ribancourt paid particular attention to the process for making black ink, and from his experiments he draws the following inferences:—That logwood is a useful ingredient in ink, because its colouring matter is disposed

to unite with the oxide of iron, and renders it not only of a very dark colour, but less capable of change from the action of acids, or of the air. Sulphate of copper, in a certain proportion, gives depth and firmness to the colour of the ink. Gum arabic, or any other pure gum, is of service, by retarding the precipitation of the fecule; by preventing the ink from spreading or sinking into the paper; and by affording it a kind of compact varnish, or defence from the air when dry. Sugar appears to have some bad qualities, but is of use in giving a degree of fluidity to the ink, which permits the dose of gum to be enlarged beyond what the ink would bear without it. Water is the best solvent. Lewis had supposed, that the defects of ink arise chiefly from a want of colouring matter. But the theory, grounded on the fact discovered by M. Ribaucourt, requires that none of the principles should be in excess. It is doubtful whether the principles of the galls be well extracted by maceration; and, it is certain, that inks made in this way flow pale from the pen, and are not of so deep a black as those wherein strong boiling is recurred to. From all the foregoing considerations, M. R. gives these directions for the composition of good ink:—Take eight ounces of Aleppo galls (in coarse powder); four ounces of logwood (in thin chips); four ounces of sulphate of iron: three ounces of gum arabic (in powder); one ounce of sulphate of copper; and one ounce of sugar-candy. Boil the galls and logwood together, in twelve pounds of water, for one hour, or till half the liquor has evaporated. Strain the decoction through a hair sieve, or linen cloth, and then add the other ingredients. Stir the mixture till the whole is dissolved, more especially the gum; after which, leave it to subside for twenty-four hours. Then decant the ink, and preserve it in bottles of glass or stone ware, well corked. Many recommend that the sulphate of iron should be calcined to whiteness. Mr. Desormeaux, jun., an ink manufacturer in Spital-fields, has given the following in the Philosophical Magazine, as the result of much experience:—Boil four ounces of logwood about an hour in six beer quarts of water, adding boiling water from time to time; strain while hot, and when cold add water enough to make the liquor five quarts. Into this put one pound avoirdupois of blue galls coarsely bruised, four ounces of sulphate of iron calcined to whiteness, three ounces of coarse brown sugar, six ounces of gum arabic, and a quarter of an ounce of acetate of copper, triturated with a little of the decoction to a paste, and then thoroughly mixed with the rest. This is to be kept in a bottle uncorked about a fortnight, shaking it twice a-day, after which it may be poured from the dregs, and corked up for use. Dr. Lewis uses vinegar for his menstruum, and M. Ribaucourt has sulphate of copper among his ingredients. I have found an inconvenience from the use of either, which, though it does not relate to the goodness of the ink, is sufficiently great, in their practical exhibition, to forbid their use. The acid of the vinegar acts so strongly upon the pen, that it very frequently requires mending; and the sulphate of copper has a still more unpleasant effect on the penknife. It seldom happens, when a pen requires mending, that the ink is wiped very perfectly from it: and often, when the nib only is to be taken off, it is done without wiping at all. Whenever this is the case, the ink immediately deposits a film of copper upon the knife, and by superior elective attraction of the sulphuric acid, a correspondent portion of the edge of the knife is dissolved, and it is by this means rendered incapable of cutting till it has been again set upon the hone. If a little sugar be added to ink, a copy of the writing may easily be taken off, by laying a sheet of thin unsized paper, damped with a sponge, on the written paper, and passing lightly over it a flat iron very moderately heated. Inks of other colours may be made from a strong decoction of the ingredients used in dyeing, mixed with a little alum and gum arabic. For example, a strong decoction of Brazil wood, with as much alum as it can dissolve, and a little gum, forms a good red ink. These processes consist in forming a lake, and retarding its precipitation by the gum.—(See *Lake.*) On many occasions it is of importance to employ an ink indestructible by any process, that will not equally destroy the material on which

it is applied. Mr. Close has recommended for this purpose twenty-five grains of copal in powder dissolved in two hundred grains of oil of lavender, by the assistance of gentle heat, and then mixed with two and a half grains of lampblack, and half a grain of indigo; or one hundred and twenty grains of oil of lavender, seventeen grains of copal, and sixty grains of vermillion. A little oil of lavender, or of turpentine, may be added, if the ink be found too thick. Mr. Sheldrake suggests, that a mixture of genuine asphaltum dissolved in oil of turpentine, amber varnish, and lampblack, would be still superior. When writing with common ink has been effaced by means of aqueous chlorine, the vapour of sulphuret of ammonia, or immersion in water impregnated with this sulphuret, will render it again legible. Or, if the paper that contained the writing be put into a weak solution of prussiate of potash, and when it is thoroughly wet, a little sulphuric acid be added to the liquor, so as to render it slightly acidulous, the same purpose will be answered. Mr. Haussman has given some compositions for marking pieces of cotton or linen, previous to their being bleached, which are capable of resisting every operation in the processes both of bleaching and dyeing, and consequently, might be employed in marking linen for domestic purposes. One of these consists of asphaltum dissolved in about four parts of oil of turpentine, and with this is to be mixed lampblack, or black lead in fine powder, so as to make an ink of a proper consistence for printing with types. Another, the blackish sulphate left after expelling oxygen gas from oxide of manganese with a moderate heat, being dissolved and filtered, the dark grey pasty oxide left on the filter is to be mixed with a very little solution of gum tragacanth, and the cloth marked with this is to be dipped in a solution of potash or soda, mild or caustic, in about ten parts of water. Among the amusing experiments of the art of chemistry, the exhibition of sympathetic inks holds a distinguished place. With these the writing is invisible, until some reagent gives it opacity. We shall here mention a few out of the great number, that a slight acquaintance with chemistry may suggest to the student. 1. If a weak infusion of galls be used, the writing will be invisible till the paper be moistened with a weak solution of sulphate of iron. It then becomes black, because these ingredients form ink. 2. If paper be soaked in a weak infusion of galls, and dried, a pen dipped in the solution of sulphate of iron will write black on that paper, but colourless on any other. 3. The diluted solutions of gold and silver remain colourless upon the paper, till exposed to the sun's light, which gives a dark colour to the oxides, and renders them visible. 4. Most of the acids, or saline solutions, being diluted, and used to write with, become visible by heating before the fire, which concentrates them, and assists their action on the paper. 4. Diluted prussiate of potash affords blue letters when wetted with the solution of sulphate of iron. 6. The solution of cobalt in aqua regia, when diluted, affords an ink which becomes green when held to the fire, but disappears again when suffered to get cool. This has been used in fanciful drawings of trees, the green leaves of which appear when warm, and vanish again by cold. If the heat be continued too long after the letters appear, it renders them permanent. 7. If oxide of cobalt be dissolved in acetic acid, and a little nitre added, the solution will exhibit a pale rose colour when heated, which disappears on cooling. 8. A solution of equal parts of sulphate of copper and muriate of ammonia, gives a yellow colour when heated, that disappears when cold. Sympathetic inks have been proposed as the instruments of secret correspondence. But they are of little use in this respect, because the properties change by a few days remaining on the paper; most of them have more or less of a tinge when thoroughly dry; and none of them resist the test of heating the paper till it begins to be scorched.

INSECTS. Various important products are obtained from insects. The chief are, 1. Cantharides; 2. Millepedes; 3. Cochineal; 4. Kermes; 5. Lac; 6. Silk; 7. Wax.

INSTRUMENTS, (Chemical).—See *Laboratory*.

INVISIBLE COMBUSTION. This phenomenon was observed by sir Humphry Davy. When oxygen and hydrogen gases were made to unite to-

gether and inflame, water was the result of their combustion; but sir H. observed, that when these gases were made to pass through tubes of iron which were heated below redness, although no visible combustion appeared to the eye, nevertheless, the two gases united, and water was the result. The same effect resulted from the application of a low heat in a variety of ways. It hence appears, that all the results of combustion may be obtained in cases where the degree of heat is not sufficient to produce a luminous appearance. Thus, also, solid bodies may be ignited by the slow invisible combustion of different gases. In the course of a variety of experiments made on this subject by sir H. Davy, he was led to a discovery of the greatest importance by its application to the safety lamp. He found, that when the coal gas was introduced into it, and in such quantity as to put out the light, nevertheless, a fine platinum wire continued ignited for many minutes after; yet when it was removed into a dark room, it was evident that there was no flame in the cylinder. It thus appeared, that the oxygen and the coal gas in contact with the hot wire combined without flame, yet produced heat enough to preserve the wire ignited, and keep up their own secret combustion. This was farther proved by the introduction of a heated wire of platinum into a similar mixture, when it was immediately ignited, almost to whiteness, as if it had been in actual combustion, and so it continued for some time. After it was extinguished, it was found that the inflammability of the mixture was entirely lost. The wire was frequently taken out, and kept till it was no longer visibly red, and when introduced into the gas, it became instantly red-hot. Similar phenomenas resulted when the experiment was tried with mixtures of the olefiant gas and air, carbonic oxide, prussic gas, and hydrogen; and in the last case, a rapid production of water took place. Similar circumstances occurred with certain inflammable vapours, as, of ether, alcohol, oil of turpentine, and naphtha. The following very simple experiment will illustrate the subject:—Let fall a few drops of ether into a cold glass, and let a few coils of very fine platinum wire be heated at a hot poker, or at a candle, and then be brought into the glass; in some parts of it the wire will become almost white-hot, and will continue so as long as a sufficient quantity of vapour and air remain in the glass. If the slow combustion of ether be made in the dark, a pale phosphorescent light is perceived above the wire, which is most distinct when the wire ceases to be ignited. On the principle of these experiments, is founded the preparation of a lamp which exhibits light without flame. Around the tube of a small alcohol lamp twist a piece of platinum-wire, one hundredth part of an inch in diameter, and form about ten or a dozen convolutions above the tube with the same piece. This may be done by previously twisting the wire around a tobacco-pipe. Let the cotton wick be small, having its fibres loose, and standing perpendicular in the tube, but no higher than the third or fourth convolution. The coils towards the top should gradually become smaller as they approach it. The lamp should be a little more than half filled with alcohol, ether, or even camphor. Light the wick, and when the upper coils become red-hot, blow it out: all the wire above the wick will now arrive at a white heat, and continue to give out a most brilliant light as long as the alcohol, &c. continues to ascend by the capillary attraction of the cotton. In a dark room, a gentle lambent flame will be seen playing round the wire. This lamp evolves a degree of light not only sufficient to read the smallest characters, but it radiates with the intense splendour of substances undergoing combustion in oxygen gas, and is attended by heat so powerful that the alcohol often takes fire, and the lamp is spontaneously re-lighted within a few seconds after being extinguished. Lamps of this construction are sold by the philosophical instrument-makers for six shillings each. In applying this principle to the improvement of the safety lamp, sir H. Davy suspended some coils of fine platinum wire above the wick of the safety-lamp in the wire gauze cylinder. If the lamp should be extinguished by the quantity of fire damp, the glow of the platinum will continue to guide the miner; and by

placing the lamp in different parts of the gallery, the relative brightness of the wire shows the state of the atmosphere in those parts. Wherever the wire continues ignited, there is still sufficient oxygen to support respiration; for the ignition ceases when the foul air forms about two-fifths of the volume of the atmosphere. It is an advantage that the platinum wire is of a very moderate price, and that it is imperishable in its duration. If the foul air be in such quantity as to stop the ignition, whenever the lamp is taken into a purer atmosphere, it again commences; and if the air become sufficiently pure, it will ignite so as again to light the wick of the lamp, which the fire damp had extinguished.

IODIC ACID, may be obtained in the following way:—Let barytes water act upon iodine, and an insoluble iodate of barytes will result. Wash it, and pour upon it sulphuric acid equal to the barytes present, and heat the mixture. The iodic acid will quickly abandon its base, and mix with the water; but a little of the sulphuric acid will also be mixed with it. Add barytes water, and the two acids precipitate together. The density of iodic acid is greater than that of sulphuric acid. Expose it to a heat of from 600 to 700 deg. and it is melted and decomposed into oxygen and iodine. It deliquesces in air, and is very soluble in water. It destroys vegetable colours. The concentration of the liquid acid of gay lussac was of the consistence of a syrup, but sir H. Davy obtained this acid in the form of a solid. It forms combinations with all the fluid and solid acids which it does not decompose.

IODINE, was discovered in Paris by M. de Courtois, a saltpetre manufacturer, who observed a rapid corrosion of his metal pots in preparing different sorts of sea-weeds, which he used in making carbonate of soda. It is from sea-weeds alone that this product of nature is to be obtained. It has not yet been decomposed. For the purpose of experiments, it may be thus procured: Digest eight ounces of pulverized kelp in a quart of water, and filter it through paper. Evaporate it by a gentle heat, in a Wedgwood's vessel, the muriate of soda will be formed into crystals at the bottom. Mix four ounces of sulphuric acid with the uncrystallized solution; and boil it for about five minutes: next put this mixture into a tubulated retort with four ounces of the black oxide of manganese, and place the whole over a lamp; let a receiver be attached to it, and the iodine will soon rise in the form of a violet-coloured vapour, and will be condensed on the sides of the receiver in dark, shining, spiculæ, something like plumbago. Preserve it in a phial, having a ground stopper. Iodine is of a greyish black colour and metallic lustre. It is soft and friable to the touch. Its taste is very acrid. It is a deadly poison. It gives a brown stain to the skin, which soon vanishes by evaporation. The sp. gr. of iodine at 62½ deg. is 4·948. It dissolves in 7000 parts of water, and the solution is of an orange-yellow colour. Iodine is incombustible, but with azote it forms a detonating compound; and in combining with several bodies, it produces the phenomena of combustion. The oxide of sodium, and the subcarbonate of soda, are completely decomposed by iodine. M. Gay Lussac says, "Sulphate of potash was not altered by iodine; but, what may appear astonishing, I obtained oxygen with the fluate of potash, and the glass tube in which the operation was conducted was corroded. On examining the circumstances of the experiment, I ascertained that the fluate became akaline when melted in a platinum crucible. This happened to the fluate over which I passed iodine. It appears then, that the iodine acts upon the excess of alkali, and decomposes it. The heat produced disengages a new portion of fluoric acid or its radical, which corrodes the glass; and thus by degrees the fluate is entirely decomposed. These facts seem to give countenance to the opinion, that the fluoric is an oxygen acid; and that the salt called fluate of potash is not a fluoride of potassium. Iodine forms with sulphur, a compound of a greyish-black colour, radiated like sulphuret of antimony. Iodine and phosphorus combine with great rapidity at common temperatures, and produce heat without light. Oxygen expels iodine from both sulphur and phosphorus. Hydrogen, whether dry or moist, does not seem to have any action on iodine at the ordinary temperature; but if we expose a mixture

of hydrogen and iodine to a red-heat in a tube, they unite together, and hydriodic acid is produced, which gives a reddish-brown colour to water. Charcoal has no action upon iodine. Several of the metals, as zinc, iron, tin, mercury, attack it readily, even at a low temperature, provided they be in a divided state: they produce but little heat, and but rarely any light. Iron is acted on by iodine in the same way as zinc; and a brown iodide results. Antimony presents, with iodine, the same phenomena as tin. The iodides of lead, copper, bismuth, silver, and mercury, are insoluble in water. This is at least the case with the above mentioned metals. There are two iodides of mercury; the one yellow, the other red; both are fusible and volatile. When iodine and oxides act upon each other in contact with water; its hydrogen unites with iodine, to form hydriodic acid; while its oxygen, on the other hand, produces with iodine, iodic acid. Iodide of mercury has been proposed for a pigment; in other respects, iodine has not been applied to any purpose of common life.

IRIDIUM. Mr. Tennant, on examining the black powder left after dissolving platina, which, from its appearance, had been supposed to consist chiefly of plumbago, found it contained two distinct metals, never before noticed, which he has named iridium and osmium. The former of these was observed soon after by Descotils, and by Vauquelin. To analyze the black powder, Mr. Tennant put it into a silver crucible, with a large proportion of pure dry soda, and kept it in a red-heat for some time. The alkali being then dissolved in water, it had acquired a deep orange or brownish yellow colour, but much of the powder remained undissolved. This digested in muriatic acid, gave a dark blue solution, which afterward became of a dusky olive green; and finally, by continuing the heat, of a deep red. The residuum being treated as before with alkali, and so on, alternately, the whole appeared capable of solution. As some silex continued to be taken up by the alkali, till the whole of the metal was dissolved, it seems to have been chemically combined with it. The alkaline solution contains oxide of osmium, with a small proportion of iridium, which separates spontaneously in dark coloured thin flakes by keeping it some weeks. The acid solution contains likewise both the metals, but chiefly iridium. By slow evaporation, it affords an imperfectly crystallized mass; which, being dried on blotting-paper, and dissolved in water, gives, by evaporation, distinct octohedral crystals. These crystals, dissolved in water, produce a deep red solution, inclining to orange. Infusion of galls occasions no precipitate, but instantly renders the solution almost colourless. Muriate of tin, carbonate of soda, and prussiate of potash, produce nearly the same effect. Ammonia precipitates the oxide, but, possibly from being in excess, retains a part in solution, acquiring a purple colour. The fixed alkalis precipitate the greater part of the oxide, but retain a part in solution, this becoming yellow. All the metals that Mr. Tennant tried, except gold and platina, produced a dark or black precipitate from the muriatic solution, and left it colourless. The iridium may be obtained pure, by exposing the octohedral crystals to heat, which expels the oxygen and muriatic acid. It was white, and could not be melted by any heat Mr. Tennant could employ. It did not combine with sulphur, or with arsenic. Lead unites with it easily, but is separated by cupellation, leaving the iridium on the cupel as a coarse black powder. Copper forms with it a very malleable alloy, which, after cupellation, with the addition of lead, leaves a small proportion of the iridium, but much less than in the preceding instance. Silver forms with it a perfectly malleable compound, the surface of which is tarnished merely by cupellation; yet the iridium appears to be diffused through it in fine powder only. Gold remains malleable, and little altered in colour, though alloyed with a considerable proportion nor is it separable either by cupellation or quartation. If the gold or silver be dissolved, the iridium is left as a black powder. The French chemists observed that this new metal gave a red colour to the triple salt of platina and sal ammoniac, was not altered by muriate of tin, and was precipitated of a dark brown by caustic alkali. Vauquelin added, that it

was precipitated by galls, and by prussiate of potash; but Mr. Tennant ascribes this to some impurity. Mr. Tennant gave it the name of iridium, from the striking variety of colours it affords while dissolving in muriatic acid. Dr. Wollaston has observed, that among the grains of crude platina, there are some scarcely distinguishable from the rest but by their insolubility in nitro-muriatic acid. They are harder, however, when tried by the file; not in the least malleable; and of the specific gravity of 19·5. These appeared to him to be an ore, consisting entirely of two new metals.

IRON, is a metal of a bluish white colour, of considerable hardness and elasticity; very malleable, and exceedingly tenacious and ductile. This metal is easily oxidized. A piece of iron wire, immersed in a jar of oxygen gas, being ignited at one end, will be entirely consumed by the successive combustion of its parts. It requires a very intense heat to fuse it. On which account it can only be brought into the shape of tools and utensils by hammering. This high degree of infusibility would deprive it of the most valuable property of metals; namely, the uniting of smaller masses into one, if it did not possess another singular and advantageous property, which is found in no other metal except platina; namely, that of welding. In a white heat, iron appears as if covered with a kind of varnish; and in this state if two pieces be applied together, they will adhere, and may be perfectly united by forging. When iron is exposed to the action of moist air or water, it acquires weight by gradual oxidation, and hydrogen gas escapes; this is a very slow operation. But if the steam of water be made to pass through a red-hot gun barrel, or through an ignited copper or glass tube, containing iron wire, the iron becomes converted into an oxide, while hydrogen gas passes out at the other end of the barrel. By the action of stronger heat this becomes a reddish-brown oxide. The yellow rust, formed when iron is long exposed to damp air, is not a simple oxide, as it contains a portion of carbonic acid. The concentrated sulphuric acid scarcely acts on iron, unless it is boiling. If the acid be diluted with two or three parts of water, it dissolves iron readily, without the assistance of heat. During this solution, hydrogen gas escapes in large quantities. The green sulphate of iron is much more soluble in hot than cold water; and therefore crystallizes by cooling, as well as by evaporation. The crystals are efflorescent and fall into a white powder by exposure to a dry air, the iron becoming more oxidized than before. A solution of sulphate of iron, exposed to the air, imbibes oxygen; and a portion of the iron, becoming peroxidized, falls to the bottom. Sulphate of iron is not made in the direct way, because it can be obtained at less charge from the decomposition of martial pyrites. It exists in two states, one containing oxide of iron, with 0·22 of oxygen, which is of a pale green, not altered by gallic acid, and giving a white precipitate with prussiate of potash. The other, in which the iron is combined with 0·30 of oxygen, is red, not crystallizable, and gives a black precipitate with gallic acid, and a blue with prussiate of potash. In the common sulphate, these two are often mixed in various proportions. Sulphate of iron is decomposed by alkalis and by lime. Caustic fixed alkali precipitates the iron in deep green flocks, which are dissolved by the addition of more alkali, and form a red tincture. Vegetable astringent matters, such as nutgalls the husks of nuts, logwood, tea, &c. which contain tannin and gallic acid, precipitate a fine black fecula from sulphate of iron, which remains suspended for a considerable time in the fluid, by the addition of gum arabic. This fluid is well known by the name of ink. The beautiful pigment, well known in the arts by the name of prussian blue, is likewise a precipitate afforded by sulphate of iron. Concentrated nitric acid acts very strongly upon iron filings, much nitrous gas being disengaged at the same time. The solution is of a reddish brown, and deposits the oxide of iron after a certain time; more especially if the vessel be left exposed to the air. A diluted nitric acid affords a more permanent solution of iron of a greenish colour, or sometimes of a yellow colour. Neither of the solutions afford crystals, but both deposit the oxide of iron by boiling, at the same time that the fluid assumes a

gelatinous appearance. Diluted muriatic acid rapidly dissolves iron at the same time that a large quantity of hydrogen is disengaged, and the mixture becomes hot. If iron filings be triturated with muriate of ammonia, moistening the mixture; then drying, powdering, and again triturating; and lastly subliming with a heat quickly raised; yellow or orange coloured flowers will rise, consisting of a mixture of muriate of ammonia, with more or less muriate of iron. These, which were called flowers of steel, and still more improperly *ens veneris*, were once much esteemed; but are now little used, as they are nauseous in solution, and cannot very conveniently be given in any other form. Carbonic acid, dissolved in water, combines with a considerable quantity of iron, in proportion to its mass. Phosphoric acid unites with iron, but very slowly. The union is best effected by adding an alkaline phosphate to a solution of one of the salts of iron, when it will fall down in a white precipitate. This acid is found combined with iron in the bog ores, and being at first taken for a peculiar metal, was called siderite by Bergman. Liquid fluoric acid attacks iron with violence; the solution is not crystallizable, but thickens to a jelly, which may be rendered solid by continuing the heat. The acid may be expelled by heating it strongly, leaving a fine red oxide. Borate of iron may be obtained by precipitating a solution of the sulphate with neutral borate of soda. Arsenic acid likewise unites with iron. This arseniate is found native. Chromate of iron has been found in the department of Var in France, and elsewhere. Sulphur combines very readily with iron. A mixture of iron filings and flowers of sulphur being moistened or made into a paste, with water, becomes hot, swells, adheres together, breaks, and emits watery vapours, of an hepatic smell. If the mixture be considerable in quantity, as, for example, one hundred pounds, it takes fire in twenty or thirty hours, as soon as the aqueous vapours cease. By fusion with iron, sulphur produces a compound of the same nature as the pyrites, and exhibiting the same radiated structure when broken. If a bar of iron be heated to whiteness, and then touched with a roll of sulphur, the two substances combine, and drop down together in a fluid state. Mr. Hatchett found, that the magnetical pyrites contains the same proportion as the artificial sulphuret. Phosphorus may be combined with iron by adding it, cut into small pieces, to fine iron wire heated moderately red in a crucible; or by fusing six parts of iron clippings, with six of glacial phosphoric acid, and one of charcoal powder. This phosphuret is magnetic; and Mr. Hatchett remarks, that iron, which in its soft or pure state cannot retain magnetism, is enabled to do so when hardened by carbon, sulphur, or phosphorus, unless the dose be so great as to destroy the magnetic property, as in most of the natural pyrites and plumbago. The combination of carbon with iron is of all the most important, and under the names of cast-iron and steel, will be considered in the latter part of the present article. Iron unites with gold, silver, and platina. When heated to a white-heat, and plunged in mercury, it becomes covered with a coating of that metal. Mr. A. Aitken unites an amalgam of zinc and mercury with iron filings, and then adds muriate of iron, when a decomposition takes place, the muriatic acid combining with the zinc, and the amalgam of iron and mercury assuming the metallic lustre by kneading, assisted with heat. Iron and tin very readily unite together. Iron does not unite easily with bismuth, at least in the direct way. This alloy is brittle and attractable by the magnet, even with three-fourths of bismuth. As nickel cannot be purified from iron without the greatest difficulty, it may be presumed that these substances readily unite. Arsenic forms a brittle substance in its combination with iron. Cobalt forms a hard mixture with iron, which is not easily broken. Manganese is almost always united with iron in the native state. Tungsten forms a brittle, whitish-brown, hard alloy, of a compact texture, when fused with white crude iron. The habitudes of iron with molybdena are not known. Iron is the most diffused, and the most abundant of metallic substances. Few mineral bodies or stones are without an admixture of this metal. Sands, clays, the waters of rivers and springs are scarcely ever perfectly free from

it. The parts of animal and vegetable substances likewise afford iron in the residues they leave after incineration. It has been found native, in large masses, in Siberia, and in the internal parts of South America. This metal, however, in its native state, is scarce: most iron is found in the state of oxide, in ochres, bog ores, and other friable earthy substances, of a red, brown, yellow, or black colour. The magnet or loadstone, is an iron ore. Iron is also found in combination with the sulphuric acid, either dissolved in water, or in the form of sulphate. In the large iron-works, it is usual to roast or calcine the ores of iron, previous to their fusion; as well for the purpose of expelling sulphurous or arsenical parts, as to render them more easily broken into fragments of a convenient size for melting. The mineral is melted or run down, in large furnaces, from 16 to 30 feet high; and variously shaped, either conical or elliptical, according to the opinion of the iron-master. Near the bottom of the furnace is an aperture for the insertion of the pipe of large bellows, worked by water or steam, or of other machines for producing a current of air; and there are also holes at proper parts of the edifice, to be occasionally opened, to permit the scoriæ and the metal to flow out, as the process may require. Charcoal or coke, with lighted brushwood, is first thrown in; and when the whole inside of the furnace has acquired a strong ignition, the ore is thrown in, by small quantities at a time, with more of the fuel, and commonly a portion of limestone, as a flux, the ore gradually subsides into the hottest part of the furnace, where it becomes fused—the earthy part being converted into a kind of glass, while the metallic part is reduced by the coal, and falls through the vitreous matter to the lowest place. The quantity of fuel, the additions, and the heat, must be regulated in order to obtain iron of any desired quality; and this quality must likewise, in the first product, be necessarily, different, according to the nature of the parts which compose the ore. The iron which is obtained from the smelting furnaces is not pure, and may be distinguished into three states: white crude iron, which is brilliant in its fracture, and exhibits a crystallized texture, more brittle than the other kinds, not at all malleable, and so hard as perfectly to withstand the file; grey crude iron, which exhibits a granulated and dull texture when broken; this substance is not so hard and brittle as the former, and is used in the fabrication of artillery and other articles which require to be bored, turned, or repaired; and black cast-iron, which is still rougher in its fracture, its parts adhere together less perfectly than those of the grey crude iron. In order to convert it into malleable iron, it is placed on a hearth, in the midst of charcoal, urged by the wind of two pair of bellows. As soon as it becomes fused, a workman continually stirs it with a long iron instrument. During the course of several hours it becomes gradually less fusible, and assumes the consistence of paste. In this state it is carried to a large hammer, the repeated blows of which drive out all the parts that still partake of the nature of crude iron so much as to retain the fluid state. By repeated heating and hammering, more of the fusible iron is forced out, and the remainder being malleable, is formed into a bar, or other form, for sale. Crude iron loses upwards of one-fourth of its weight in the process of refining; sometimes, indeed, one-half. Purified or bar-iron is soft, ductile, flexible, malleable, and possesses all the qualities which have been enumerated under this article as belonging exclusively to iron. When a bar of iron is broken, its texture appears fibrous—a property which depends upon the mechanical action of the hammer, while the metal is cold. Ignition destroys this fibrous texture, and renders the iron more uniform throughout; but hammering restores it. If the purest malleable iron be bedded in pounded charcoal, in a covered crucible, and kept for a certain number of hours in a strong red-heat, (which time must be longer or shorter, according to the greater or less thickness of the bars of iron) it is found, that by this operation, which is called cementation, the iron has gained a small addition of weight, amounting to about the hundred-and-fiftieth, or the two-hundredth part, and is remarkably changed in its properties. It is much more brittle and fusible than before. Its surface is commonly blistered when it comes out of the crucible, and it requires to

be forged, to bring its parts together into a firm and continuous state. This cemented iron is called steel. It may be welded like bar-iron, if it has not been fused, or over-cemented; but its most useful and advantageous property is that of becoming extremely hard when ignited and plunged into cold water. The hardness produced is greater in proportion as the steel is hotter, and the water colder. The colours which appear on the surface of steel slowly heated, are yellowish-white, yellow, gold-colour, purple, violet, deep blue, yellowish-white; after which the ignition takes place. These signs direct the artist in tempering or reducing the hardness of steel to any determinate standard. If steel be too hard, it will not be proper for tools which are intended to have a fine edge, because it will be so brittle, that the edge will soon become notched; if it be too soft, it is evident that the edge will bend or turn. Some artists ignite their tools, and plunge them into cold water; after which, they brighten the surface of the steel upon a stone; the tool being then laid upon charcoal, or upon the surface of melted lead, or placed in the flame of a candle, gradually acquires the desired colour, at which insta t they plunge it into water. If a hard temper be desired, the piece is dipped again, and stirred about in the cold water as soon as the yellow tinge appears. If the purple appear before the dipping, the temper will be fit for gravers, and tools used in working upon metals; if dipped while blue, it will be proper for springs, and for instruments used in the cutting of soft substances, such as cork, leather, and the like; but if the last pale colour be waited for, the hardness of the steel will scarcely exceed that of iron. When soft steel is heated to any one of these colours, and then plunged into water, it does not acquire nearly so great a degree of hardness, as if previously made quite hard, and then reduced by tempering. The degree of ignition required to harden steel, is different in the different kinds. The best kinds require only a low red-heat. The harder the steel, the more coarse and granulated its fracture will be; and as this is not completely remedied by the subsequent tempering, it is advisable to employ the least heat capable of affording the requisite hardness. The usual time required for the cementation of steel is from six to ten hours. If the cementation be continued too long, the steel becomes porous, brittle, of a darker fracture, more fusible, and incapable of being forged or welded. On the contrary, steel cemented with earthy infusible powders, is gradually reduced to the state of forged iron again. Simple ignition produces the same effect, but is attended with oxidation of the surface. The texture of steel is rendered more uniform by fusing it before it is made into bars; this is called cast steel, and is rather more difficultly wrought than common steel, because it is more fusible, and is dispersed under the hammer if heated to a white-heat. The English steel made by cementation, and afterwards fused, and sold under the name of cast steel, in bars, plates, and other forms, possesses great reputation for its uniformity of texture, and other good qualities. It has been stated by various authorities, of which the respectability and connections are calculated to produce the most absolute confidence, that all the prime steels of England are made from Swedish iron, known in this country by the name of steel iron, of three different marks, the first of which indicates the best quality, and the third the worst. The conversion of iron into steel, either by fusion, viz. the direct change of crude iron into steel, or by cementation of bar iron, presents many objects of interesting inquiry. From various experiments of Bergman, it appeared, that good crude iron, kept for a certain time in a state of fusion, with such additions as appeared calculated to produce little other effect than that of defending the metal from oxidation, became converted into steel, with loss of weight. These facts are conformable to the general theory of Vandermonde, Monge, and Berthollet; for, according to their researches, it should follow that part of the carbon in the crude iron was dissipated, and the remainder proved to be such in proportion as constitutes steel. The same chemist cemented crude iron with plumbago, or carbonate of iron, and found that the metal had lost no weight. Morveau repeated the experiment with grey crude iron. The loss of weight was little, if any. The metal exhibited the black spot, by the application of

nitric acid, as steel usually does, but it did not harden by ignition and plunging in water. Hence it is concluded, that it was scarcely altered; for crude irons also exhibit the black spot, and cannot by common management acquire the hardness of steel. By pursuing this train of reflection, it will follow, that since crude iron differs from steel only in the superabundance of carbon, it ought to be capable of extreme hardness, if ignited to that degree which is requisite to combine the greater part of this carbon with the iron, and then suddenly cooled. This is accordingly found to be the case. If the grey crude iron, commonly distinguished by our founders by the name of soft metal, be heated to a white-heat, and then plunged into water, it becomes very hard, much whiter, denser, and more metallic in its appearance, and will bear a pretty good edge, fit for gravers, for the use of turners in iron or steel. In these tools the angle of the planes which form the edge is about 45 deg. The hardness of this kind of iron is not considerably diminished but by ignition continued for a length of time, which is a fact also conformable to what happens in steel. For the cast steel will be softened nearly as much by annealing to the straw colour, as the harder steels are by annealing to a purple or full blue. Some of our artists have taken advantage of this property of soft crude iron, in the fabrication of axles and collars for wheel-work; for this material is easily filed and turned in its soft state, and may afterwards be hardened so as to endure a much longer time of wear. The founders who cast wheels and other articles of mechanism, are occasionally embarrassed by this property. For, as the metal is poured into their moulds of moistened sand, the evaporation of the water carries off a great portion of the heat, and cools the iron so speedily, as to render it extremely hard, white, and close in its texture. This is most remarkable in such portions of the metal as have the greatest distance to run from the git or aperture of reception. For these come in contact successively with a larger portion of the sand, and are therefore more suddenly cooled. We may see the teeth of cog-wheels altogether in this state, while the rim and other parts of the wheel remained soft. The obvious remedy for this defect is to increase the number of gits, and to have the sand as dry as possible or convenient. In other articles this property has been applied to advantage, particularly in the steel rollers for large laminating mills. It has been stated by a workman, that ignited iron, suddenly plunged into the soft leather of a shoe, becomes very hard on its surface, which must arise from an instantaneous effect of case-hardening. The increase of dimensions acquired by steel in hardening, is such, that in general, pieces of work finished soft will not fit their places when hardened. The fineness of grain in hard steel, as exhibited in its fracture, is various according to the quality of the metal, and the temper it has received. The harder the steel, the coarser the grain. But in like circumstances, fine steel has the closest grain, and is ever the most uniform in its appearance. Workmen avail themselves much of this indication. In general, a neat curve lined fracture, and even grey texture, denote good steel, and the appearance of threads, cracks, or brilliant specks, denotes the contrary. But the management of the forging, and other circumstances of manufacturing, will modify these indications; and the steel that is good for some purposes, may be less suited to others. It is found, that steel is more effectually hardened in cold than in warm water, and, at like temperatures, more effectually in mercury than in water. Oil is found to harden the surface of steel much more than its internal part, so that it resists the file, but is much less easily broken by the hammer. Tallow differs from oil in the heat, which becomes latent for its fusion; and accordingly, solid tallow is an excellent material for hardening drills and other small articles. The makers of files cover them with the grounds of beer and common salt, which assist their hardening, and keep the surface from scorifying. The mucilage of the beer supplies a coally matter, and the fused salt forms a varnish in the fire, and defends the steel. Very small articles heated in a candle are found to be hardened perfectly, by suddenly whirling them in the cold air; and thin bars or plates of steel, such as the magnetic needle of a compass, acquire a good

degree of hardness by being ignited, then laid on a plate of cold lead, and suddenly covered with another plate. These would be unequally hardened, and bend, if plunged in water. The black spot which remains upon steel, or crude iron, after its surface has been corroded by acids, consists of plumbago, which remains after the iron has disappeared by solution. Solution in the sulphuric or muriatic acid not only exhibits the plumbago contained in iron, but likewise possesses the advantage of shewing the state of its reduction, by the quantity of hydrogen gas which is disengaged; for the quantity of this gas, in like circumstances, is proportional to that of the iron which is converted into oxide. It is found that the white crude iron affords the least quantity of hydrogen in proportion to its bulk, and leaves a moderate portion of plumbago; the grey crude iron affords more hydrogen and more plumbago than the white; and the softest bar iron affords most hydrogen of any, and little or no plumbago. The quantities of hydrogen gas, at a medium, by ounce measures, were 62, afforded by 100 grains of the white crude iron; 71 by the grey crude iron, and 77 by the malleable iron. Iron is one of the principal ingredients for dyeing black. The stuff is first prepared with a bath of galls and logwood, then with a similar bath, to which verdegris is added, and lastly dyed in a similar bath, with the addition of sulphate of iron. If it be wished that the colour should be particularly fine, the stuff should previously be dyed of a deep blue; otherwise, a brown may be first given with the green husks of walnuts. Silk, however, must not be previously blued with indigo, and sumach may be substituted instead of galls. Leather, prepared by tanning with oak bark, is blackened by a solution of sulphate of iron. Cotton has a very strong affinity for oxide of iron, so that, if it be immersed in a solution of any salt of iron, it assumes a chamois colour, more or less deep according to the strength of the solution. The action of the air on the oxide of iron, deepens the colour; and if the shade were at first deep, the texture of the stuff is liable to be corroded by it. To prevent this, the cotton should be immersed in the solution cold, carefully wrung, and immediately plunged into a ley of potash, mixed with a solution of alum. After having lain in this four or five hours, it is to be wrung, washed, and dried. In order to prevent gun-barrels from rusting, they are frequently browned. This is done by rubbing it over when finished with aquafortis or spirit of salt diluted with water, and laying it by for a week or two, till a complete coat of rust is formed. A little oil is then applied, and the surface being rubbed dry, is polished by means of a hard brush and a little bees' wax. The yellow spots called iron moulds, which are frequently occasioned by washing ink spots with soap, may in general be removed by lemon-juice, or the oxalic or citric acids, or by muriatic acid diluted with five or six parts of water; but this must be washed off in a minute or two. Ink spots may readily be removed by the same means. If the iron mould have remained so long, that the iron is very highly oxidized, so as to be insoluble in the acid, a solution of an alkaline sulphuret may be applied, and after this has been well washed off, the acid will remove the stain. The specific gravity of pure iron is 7·7, which may be a little increased by hammering. It is less malleable than gold, silver, or copper, but it is nearly as ductile, wire being made of iron, of the diameter of the one hundred and fiftieth part of an inch. Iron combines with oxygen, in different proportions, also with chlorine, iodine, sulphur, and carbon. Iron united with carbon becomes steel. Cast iron contains a portion of carbon, with some other substances. The most useful alloy of iron is that with tin or tin-plate. Alloys are produced of steel, with platinum, rhodium, gold, silver, and nickel. Iron is a valuable article in the materia medica. Chalybeate springs greatly benefit the constitution, and they derive their virtues from the quantity of iron diffused through them by the agency of a mild acid, in which state it is readily taken up by the lacteals. To imitate the water of a good chalybeate spring, dissolve 3 grains of the sulphate of iron, and 60 of bicarbonate of potass, in a quantity of cold water, and agitate in a close vessel.

IRON FLINT, consists of 93·5 silica, 5 oxide of iron, and 1 volatile matter. Another kind, called red iron

flint, consists of 76·8 silica, and 21·7 oxide of iron.

ISATIS TINCTORIA, the plant called woad, used in dyeing.

ISERINE, a mineral of an iron-black colour, consisting of 48 oxide of titanium, 48 oxide of iron, and 4 uranium, according to the analysis of Dr. Thomson, of iserine found in the river Don, in Aberdeenshire. According to Klaproth, it consists of 72 oxide of iron, and 28 oxide of titanium. Specific gravity, 4·6. The mineral acids have no effect on it.

ISINGLASS. This substance is almost wholly gelatine; 100 grains of good dry isinglass containing rather more than 98 of matter soluble in water. Isinglass is made from certain fish found in the Danube, and the rivers of Muscovy. Willoughby and others inform us, that it is made of the sound of the Beluga; and Neumann, that it is made of the Huso Germanorum, and other fish, which he has frequently seen sold in the public markets of Vienna. Mr. Jackson remarks, that the sounds of cod, properly prepared, afford this substance; and that the lakes of America abound with fish from which the very finest sort may be obtained. Isinglass receives its different shapes in the following manner:—The parts of which it is composed, particularly the sounds, are taken from the fish while sweet and fresh, slit open, washed from their slimy sordes, divested of a very thin membrane which envelopes the sound, and then exposed to stiffen a little in the air. In this state, they are formed into rolls about the thickness of a finger, and in length according to the intended size of the staple: a thin membrane is generally selected for the centre of the roll, round which the rest are folded alternately, and about half an inch of each extremity of the roll is turned inwards. Isinglass is best made in the summer, as frost gives it a disagreeable colour, deprives it of its weight, and impairs its gelatinous principles. Isinglass boiled in milk forms a mild nutritious jelly, and is thus sometimes employed medicinally. This, when flavoured by the art of the cook, is the blanc-mange of our tables. A solution of isinglass in water, with a very small proportion of some balsam, spread on black silk, is the court plaister of the shops.

IVORY. The tusk, or tooth of defence of the male elephant. It is an intermediate substance, between bone and horn, not capable of being softened by fire, not altogether so hard and brittle as bone. Sometimes it grows to an enormous size, so as to weigh near two hundred pounds. The entire tooth is of a yellowish, brownish, and sometimes a dark brown colour on the outside, internally white, hollow towards the root, and so far as was inserted into the jaw, of a blackish brown-colour. The finest, whitest, smoothest, and most compact ivory comes from the island of Ceylon. The grand consumption of this commodity is for making ornamental utensils, mathematical instruments, cases, boxes, balls, combs, dice, and an infinity of toys. The workmen have methods also of tingeing it of a variety of colours. Merat Guillot obtained from 100 parts of ivory, 24 gelatine, 64 phosphate of lime, and 0·1 carbonate of lime. The coal of ivory is used in the arts under the denomination of ivory-black. Particular vessels are used in the manufactory of this pigment, for the purpose of rendering it perfectly black. Some travellers speak of the tooth of the sea-horse as an excellent ivory; but it is too hard to be sawed or wrought like ivory. It is used for making artificial teeth.

K

KALI. —See Potash.

KAOLIN. The Chinese name of porcelain clay.

KEDRIA TERRESTRIS. Barbadoes tar.—(See *Bitumen*.)

KELP. Incinerated sea weed.—(See *Soda*.)

KERMES (*coccus ilicis*, Lin.) is an insect found in many parts of Asia, and the south of Europe. On account of their figure, they were a long time taken for the seeds of the tree on which they live; whence they were called grains of kermes. They also bore the name of vermilion. To dye spun worsted with kermes, it is first boiled half an hour in water with bran, then two hours in a fresh bath with one-fifth of Roman alum, and one-tenth of tartar, to which sour water is

commonly added; after which, it is taken out, tied up in a linen bag, and carried to a cool place, where it is left some days. To obtain a full colour, as much kermes as equals three-fourths, or even the whole of the weight of the wool, is put into a warm bath, and the wool is put in at the first boiling. As cloth is more dense than wool, either spun or in the fleece, it requires one-fourth less of the salts in the boiling, and of kermes in the bath. The colour that kermes imparts to wool has much less bloom than the scarlet made with cochineal; whence the latter has generally been preferred, since the art of heightening its colour by means of solution of tin has been known.

KERMES MINERAL. (See *Antimony.*)

KIFFEKILL. (See *Meerschaum.*)

KINATE OF LIME. A salt which forms 7 per cent. of cinchona. (See *Kinic Acid.*)

KINIC ACID, was obtained by Vauquelin from the extract of cinchona, made from infusions of the bark in hot water. Alcohol removes the resinous part, and the remainder consists of kinate of lime and a mucilaginous matter. If this residue be dissolved in water, and filtrated, and left to evaporation, it will form crystals of kinate of lime. Let them be purified by a second solution and crystalization. Let them again be dissolved in ten times their weight of water, and pour in oxalic acid, the oxolate of lime will be separated, and by spontaneous evaporation, the kinic acid will yield regular crystals.

KINO. A few years ago this was introduced into our shops and medical practice by the name of a gum; but Dr. Duncan has shown that it is an extract. It contains also a species of tannin, whence it is used as an astringent in diarrhœas.

KLEBSCHIEFER. Adhesive slate.

KONITE.—See *Limestone* and *Marble.*

KOUMISS. A vinous liquid, which the Tartars make by fermenting mares' milk. Something similar is prepared in Orkney and Shetland.

KUPFER NICKEL.—See *Nickel.*

L.

LABDANUM. A resin of a species of cistus in Candia, of a blackish colour. The country people collect it by means of a staff, at the end of which are fastened many leather thongs, which they gently strike on the trees. They form it into cylindrical pieces, which are called labdanum in tortis. It is greatly adulterated by the addition of black sand. It has been used in cephalic and stomachic plaisters and perfumes.

LABORATORY. A place properly fitted up for the performance of chemical operations. As chemistry is a science founded entirely on experiment, we cannot hope to understand it well, without making such experiments as verify most of the known fundamental operations, and also such as reasoning, analogy, and the spirit of inquiry, never fail to suggest to those, whose taste and suitable talents lead them to this essential part of experimental philosophy. Besides, when a person himself observes, and operates, he must perceive, even in the most common operations, a great variety of small facts, which must necessarily be known, but which are not mentioned either in books or in memoirs, because they are too numerous, and would appear too minute. Lastly, there are many qualities in the several agents, of which no just notion can be given by writing, and which are perfectly well known as soon as they have been once made to strike our senses. Many people think, that a laboratory level with the ground is most convenient, for the sake of water, pounding, washing, &c. It certainly has these advantages; but it is also subject to very great inconvenience from moisture. Constant moisture, though not very considerable and sensible in many respects, is a very great inconvenience in a chemical laboratory. In such a place, most saline matters become moist in time, and the inscriptions fall off, or are effaced; the bellows rot; the metals rust; the furnaces moulder, and every thing almost spoils. A laboratory, therefore, is more advantageously placed above than below the ground, that it may be as dry as pos-

sible. The air must have free access to it; and it must even be so constructed, that, by means of two or more opposite openings, a current of air may be admitted to carry off any noxious vapours or dust. In the laboratory a chimney ought to be constructed so high that a person may easily stand under it, and as extensive as is possible; that is, from one wall to another. The funnel of this chimney ought to be as high as it is possible, and sufficiently contracted to make a good draught. As charcoal only is burnt under this chimney, no soot is collected in it; and therefore it need not be so wide as to allow a chimney-sweeper to pass up into it. Under this chimney may be constructed some brick furnaces, particularly a melting furnace, a furnace for distilling with an alembic, and one or two ovens like those in kitchens. The rest of the space ought to be filled up with stands of different heights, from a foot to a foot and a half, on which portable furnaces of all kinds are to be placed. These furnaces are the most convenient, from the facility of disposing them at pleasure; and they are the only furnaces which are necessary in a small laboratory. A double pair of bellows of moderate size must also be placed as commodiously under the chimney, or as near as the place will allow. These bellows are sometimes mounted in a portable frame; which is sufficiently convenient when the bellows are not more than eighteen or twenty inches long. These bellows ought to have a pipe directed toward the hearth where the forge is to be placed. The necessary furnaces are, the simple furnace for distilling with a copper alembic; a lamp furnace; two reverberatory furnaces of different sizes, for distilling with retorts; an air or melting furnace, an essay furnace, and a forge furnace. The various instruments and vessels of indispensable use in a chemical laboratory, will be well noticed in the description of the plates attached to this volume. Under the chimney, at a convenient height, must be a row of hooks driven into the back and side walls, upon which are to be hung small shovels; iron pans; tongs; straight, crooked, and circular pincers; pokers; iron [illegible], and other utensils for disposing the fuel and managing the crucibles. To the walls of the laboratory ought to be fastened shelves of different breadths and heights; or these shelves may be suspended by hooks. The shelves are to contain glass vessels, and the products of operations, and ought to be in as great a number as is possible. In a laboratory where many experiments are made, there cannot be too many shelves. The most convenient place for a stone or leaden cistern, to contain water, is a corner of the laboratory, and under it a sink ought to be placed with a pipe, by which the water poured into it may discharge itself. As the vessels are always cleaned under this cistern, cloths and bottle brushes ought to be hung upon hooks fastened in the walls near it. In the middle of the laboratory a large table is to be placed, on which mixtures are to be made, preparations for operations, solutions, precipitations, and small filtrations; in a word, whatever does not require fire, excepting that of a lamp. In convenient parts of the laboratory are to be placed blocks of wood upon mats; one of which is to support a middle-sized iron mortar; another to support a middle-sized marble, or rather hard stone mortar; a third to support an anvil. Near the mortars are to be hung searces of different sizes and fineness; and near the anvil a hammer, files, rasps, small pincers, scissors, sheers, and other small utensils, necessary to give metals a form proper for the several operations. Two moveable trestles ought to be in a laboratory, which may serve to support a large filter mounted upon a frame, when it is required. This apparatus is removed occasionally to the most convenient place. Charcoal is an important article in a laboratory, and it therefore must be placed within reach; but as the black dust which flies about it whenever it is stirred, is apt to soil every thing in the laboratory, it had better be in some place near the laboratory, together with some furze, which is very convenient for kindling fires quickly. This place serves, at the same time, for containing bulky things, which are not often wanted; such as furnaces, bricks, tiles, clay, fire-clay, quicklime, sand, and many other things necessary for chemical operations. Lastly, a middle

Fig. 1

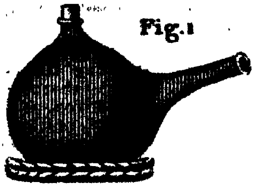


Fig. 2

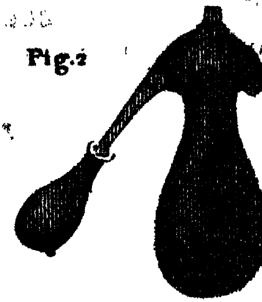


Fig. 3

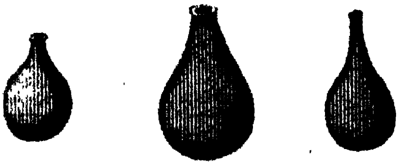


Fig. 4

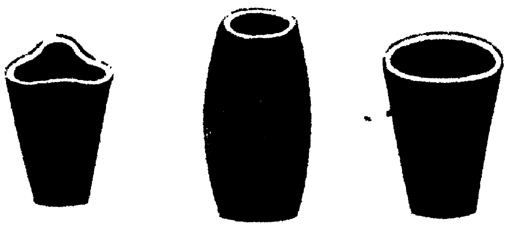
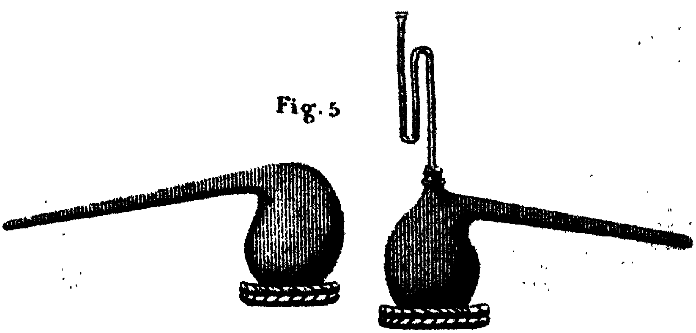


Fig. 5



sized table, with solid feet, ought to be enumerated among the large moveables of a laboratory, the use of which is to support a porphyry, or levigating stone, or rather a very hard dense grit stone, together with a muller made of the same kind of stone. The other small moveables or utensils of a laboratory are, small hand mortars of iron, glass, agate, and Wedgwood's ware, and their pestles; earthen, stone metal, and glass vessels, of different kinds, funnels, and measures. Some white writing paper, and some unsized paper for filters; a large number of clean straws, eight or ten inches long, for stirring mixtures in glasses, and for supporting paper filters placed in glass funnels. Glass tubes for stirring and mixing corrosive liquors; spatulas of wood, ivory, metal, and glass. Thin pasteboards and horns, very convenient for collecting matters bruised with water upon the levigating stone, or in mortars; corks of all sizes; bladders and linen strips for luting vessels. A good portable pair of bellows; a good steel for striking fire: a gluepot, with its little brush; lastly, a great many boxes, of various sizes, for containing most of the above-mentioned things, and which are to be placed upon the shelves. Beside these things, some substances are so necessary in most chemical operations, that they may be considered as instruments requisite for the practice of this science. These substances are called reagents. All metals, which ought to be very pure. A person provided with such instruments and substances, may at once perform many chemical experiments. The general observations of Macquer upon the conducting of chemical processes, are truly valuable and judicious. Method, order, and cleanliness are essentially necessary in a chemical laboratory. Every vessel and utensil ought to be well cleansed as often as it is used, and put again into its place; labels ought to be put upon all the substances. These cares, which seem to be trifling, are, however, very fatiguing and tedious; but they are also very important, though frequently little observed. When a person is keenly engaged, experiments succeed each other quickly; some seem nearly to decide the matter, and others suggest new ideas; he cannot but proceed to them immediately, and he is led from one to another; he thinks he shall easily know again the products of the first experiments, and therefore he does not take time to put them in order; he prosecutes with eagerness the experiments which he has last thought of; and in the mean time, the vessels employed, the glasses and bottles filled, so accumulate, that he cannot any longer distinguish them; or at least, he is uncertain concerning many of his former products. This evil is increased, if a new series of operations succeed, and occupy all the laboratory; or, if he be obliged to quit it for some time, every thing then goes into confusion. Thence it frequently happens that he loses the fruits of much labour, and that he must throw away almost all the products of his experiments. When new researches and inquiries are made, the mixtures, results, and products of all the operations ought to be kept a long time, distinctly labelled and registered; for these things, when kept some time, frequently present phenomena that were not at all suspected. Many fine discoveries in chemistry have been made in this manner, and many have certainly been lost by throwing away too hastily, or neglecting the products. Since chemistry offers many views for the improvement of many important arts, as it presents prospects of many useful and profitable discoveries, those who apply their labours in this way ought to be exceedingly circumspect, not to be led into a useless expence of money and time. In a certain set of experiments, some one is generally of an imposing appearance, although in reality it is nothing more. Chemistry is full of these half successes, which serve only to deceive the unwary, to multiply the number of trials, and to lead to great expence, before the fruitlessness of the search is discovered. By these reflections we do not intend to divert from all such researches those whose taste and talents render them fit for them; on the contrary, we acknowledge, that the improvement of the arts, and the discovery of new objects of manufacture and commerce, are undoubtedly the finest and most interesting part of chemistry, and which make that science truly valuable; for without these ends, what would chemistry be but

science purely theoretical, and capable of employing only some abstract and speculative minds, but useless to society? We acknowledge also, that the successes in this kind of chemical enquiry are not rare, and that their authors have sometimes acquired fortunes, so much the more honourable, as being the fruits of their talents and industry. But we repeat, that in these researches, the more dazzling and near any success appears, the more circumspection, and even distrust, is necessary.

LABRADOR SPAR, a species of felspar.

LAC, is a substance well known in Europe, under the different appellations of stick-lac, shell-lac, and seed-lac. The first is the lac in its natural state, encrusting small branches or twigs. Seed-lac is the stick-lac separated from the twigs, appearing in a granulated form, and probably deprived of part of its colouring matter by boiling. Shell-lac is the substance which has undergone a simple purification, as mentioned below. Beside these we sometimes meet with a fourth, called lump-lac, which is the seed-lac melted and formed into cakes. Lac is the product of the coccus lacca, which deposits its eggs on the branches of a tree called Bihar, in Assam, a country bordering on Thibet, and elsewhere in India. It appears designed to answer the purpose of defending the eggs from injury, and affording food for the maggot in a more advanced state. It is formed into cells, finished with as much art and regularity as a honeycomb, but differently arranged; and the inhabitants collect it twice a year, in the months of February and August. For the purification, it is broken into small pieces, and put into a canvas bag of about four feet long, and not above six inches in circumference. Two of these bags are in constant use, and each of them held by two men. The bag is placed over a fire, and frequently turned, till the lac is liquid enough to pass through its pores: when it is taken off the fire, and twisted in different directions by the men who hold it, at the same time dragging it along the convex part of a plantain tree prepared for this purpose; and while this is doing, the other bag is heating, to be treated in the same way. The mucilaginous and smooth surface of the plantain tree prevents its adhering; and the degree of pressure regulates the thickness of the coating of lac, at the same time that the fineness of the bag determines its clearness and transparency. Analyzed by Mr. Hatchett, stick-lac gave in 100 parts, resin 68, colouring extract 10, wax 6, gluten 5·5, extraneous substances 6·5; seed-lac, resin, 88·5, colouring extract 2·5, wax 4·5, gluten 2; shell-lac, resin 90·9, colouring extract 0·5., wax 4, gluten 2·8. The gluten greatly resembles that of wheat, if it be not precisely the same: and the wax is analogous to that of the myrica cerifera. In India, lac is fashioned into rings, beads, and other trinkets; sealing-wax, varnishes, and lakes for painters, are made from it; it is much used as a red dye, and wool tinged with it is employed as a fucus by the ladies: and the resinous part melted and mixed with about thrice its weight of finely powdered sand, forms polishing stones. The lapidaries mix powder of corundum with it in a similar manner. The colouring matter is soluble in water; but 1 part of borax to 5 of lac, renders the whole soluble by digestion in water, nearly at a boiling heat. This solution is equal for many purposes to spirit varnish, and is an excellent vehicle for water colours, as when once dried, water has no effect on it. Lixivium of potash, soda, and carbonate of soda, likewise dissolve it. So does nitric acid, if digested upon it in sufficient quantity 48 hours. The colouring matter of the lac loses considerably of its beauty by keeping any length of time; but when extracted fresh, and precipitated as a lake, it is less liable to injury. Mr. Stephens, a surgeon in Bengal, sent home a great deal prepared in this way, which afforded a good scarlet to cloth previously yellowed with quercitron; but it would probably have been better, if, instead of precipitating with alum, he had employed a solution of tin, or merely evaporated the decoction to dryness.

LACTIC ACID. By evaporating sour whey to one-eighth, filtering, precipitating with lime-water, and separating the lime by oxalic acid, Scheele obtained an aqueous solution of what he supposed to be a peculiar acid,

which has accordingly been termed the *lactic*. To procure it separate, he evaporated the solution to the consistence of honey, poured on it alcohol, filtered this solution, and evaporated the alcohol. The residuum was an acid of a yellow colour, incapable of being crystalized, attracting the humidity of the air, and forming deliquescent salts with the earths and alkalis. Bouillon Lagrange since examined it more narrowly; and from a series of experiments concluded, that it consists of acetic acid, muriate of potash, a small portion of iron, probably dissolved in the acetic acid, and an animal matter.

LACTATES, definite compounds of lactic acid, with the salifiable bases.

LACQUER, solution of lac in alcohol.

LAKE. This term is used to denote a species of colours formed by precipitating colouring matter with some earth or oxide. The principal lakes are Carmine, Florence-lake, and lake from Madder. For the preparation of Carmine, four ounces of finely pulverized cochineal are to be poured into four or six quarts of rain or distilled water, that has been previously boiled in a pewter kettle, and boiled with it for the space of six minutes longer; (some advise to add, during the boiling, two drachms of pulverised crystals of tartar). Eight scruples of Roman alum in powder are then to be added, and the whole kept upon the fire one minute longer. As soon as the gross powder has subsided to the bottom, and the decoction is become clear, the latter is to be carefully decanted into large cylindrical glasses covered over, and kept undisturbed, till a fine powder is observed to have settled at the bottom. The superincumbent liquor is then to be poured off from this powder, and the powder gradually dried. From the decanted liquor, which is still much coloured, the rest of the colouring matter may be separated by means of the solution of tin, when it yields a carmine little inferior to the other. For the preparation of Florentine lake, the sediment of cochineal that remained in the kettle may be boiled with the requisite quantity of water, and the red liquor likewise, that remained after the preparation of the carmine, mixed with it, and the whole precipitated with the solution of tin. The red precipitate must be frequently edulcorated with water. Exclusively of this, two ounces of fresh cochineal, and one of crystals of tartar, are to be boiled with a sufficient quantity of water, poured off clear, and precipitated with the solution of tin, and the precipitate washed. At the same time, two pounds of alum are also to be dissolved in water, precipitated, with a lixivium of potash, and the white earth repeatedly washed with boiling water. Finally, both precipitates are to be mixed together in their liquid state, put upon a filter, and dried. For the preparation of a cheaper sort, instead of cochineal, one pound of Brazil wood may be employed in the preceding manner. For the following process for making a lake from madder, the Society of Arts voted Sir H. C. Englefield their gold medal. Enclose two ounces troy of the finest Dutch crop madder in a bag of fine and strong calico, large enough to hold three or four times as much. Put it into a large marble or porcelain mortar, and pour on it a pint of clear soft water cold. Press the bag in every direction, and pound and rub it about with a pestle, as much as can be done without tearing it, and when the water is loaded with colour, pour it off. Repeat this process till the water comes off but slightly tinged, for which about five pints will be sufficient. Heat all the liquor in an earthen or silver vessel, till it is near boiling, and then pour it into a large basin, into which a troy ounce of alum, dissolved in a pint of boiling soft water, has been previously put. Stir the mixture together, and while stirring, pour in gently about an ounce and half of a saturated solution of subcarbonate of potash. Let it stand till cold, to settle; pour off the clear yellow liquor: add to the precipitate a quart of boiling soft water, stirring it well; and when cold, separate by filtration the lake, which should weigh half an ounce. If less alum be employed, the colour will be somewhat deeper: with less than three-fourths of an ounce, the whole of the colouring matter will not unite with the alumina. Fresh madder root is equal, if not superior to the dry. Almost all vegetable colouring matters may be precipitated into lakes, more or less beautiful, by means of alum, or oxide of tin.

LAMP.—See *Light.*

LAMP OF SAFETY.—See *Safety Lamp.*

LAMPBLACK. The finest lampblack is produced by collecting the smoke from a lamp with a long wick, which supplies more oil than can be perfectly consumed; or by suffering the flame to play against a metalline cover, which impedes the combustion, not only by conducting off part of the heat, but by obstructing the current of air. Lampblack, however, is prepared in a much cheaper way, for the demands of trade. The dregs which remain after the eliquation of pitch, or else small pieces of fir wood, are burned in furnaces of a peculiar construction, the smoke of which is made to pass through a long horizontal flue, terminating in a close boarded chamber. The roof of this chamber is made of coarse cloth, through which the current of air escapes, while the soot remains behind.

LANA PHILOSOPHICA, (Philosophical Wool). The snowy flakes of white oxide, which rise and float in the air from the combustion of zinc.

LAPIS INFERNALIS. Potash.

LAPIS LAZULI.—*Azure-stone.*

LAPIS NEPHRITICUS.—See *Nephrite.*

LAPIS OLLARIS. Potstone

LAVA.—See *Volcanoes.*

LEAD, is a white metal of a considerably blue tinge, very soft and flexible, not very tenacious, and consequently incapable of being drawn into fine wire, though it is easily extended into thin plates under the hammer. Its sp. gr. is 11·35. It melts at 612 deg. In a strong heat it boils, and emits fumes; during which time, if exposed to the air, its oxidation proceeds with considerable rapidity. Lead is brittle at the time of congelation. In this state it may be broken to pieces with a hammer, and the crystalization of its internal parts will exhibit an arrangement in parallel lines. Lead is not much altered by exposure to air or water, though the brightness of its surface, when cut or scraped, very soon goes off. It is probable that a thin stratum of oxide is formed on the surface, which defends the rest of the metal from corrosion. Most of the acids attack lead. The sulphuric does not act upon it, unless it be concentrated and boiling. Sulphurous acid gas escapes during this process, and the acid is decomposed. When the distillation is carried on to dryness, a saline white mass remains, a small portion of which is soluble in water, and is the sulphate of lead; it affords crystals. The residue of the white mass is an insoluble sulphate of lead. It consists of 5 acid + 14 protoxide. Nitric acid acts strongly on lead. Muriatic acid acts directly on lead by heat, oxidizing it and dissolving part of its oxide. The acetic acid dissolves lead and its oxides, though probably the access of air may be necessary to the solution of the metal itself in this acid. White lead, or ceruse, is made by rolling leaden plates spirally up, so as to leave the space of about an inch between each coil, and placing them vertically in earthen pots, at the bottom of which is some good vinegar. The pots are to be covered, and exposed for a length of time to a gentle heat in a sand-bath, or by bedding them in dung. The vapour of the vinegar, assisted by the tendency of the lead to combine with the oxygen which is present, corrodes the lead, and converts the external portion into a white substance which comes off in flakes, when the lead is uncoiled. The plates are thus treated repeatedly, until they are corroded through. Ceruse is the only white used in oil paintings. Commonly it is adulterated with a mixture of chalk in the shops. It may be dissolved without difficulty in the acetic acid, and affords a crystallizable salt, called sugar of lead from its sweet taste. This, like all the preparations of lead, is a deadly poison. The common sugar of lead is an acetate; and Goulard's extract, made by boiling litharge in vinegar, a subacetate. The power of this salt, as a coagulator of mucus, is superior to the other. If a bit of zinc be suspended by brass or iron wire, or a thread, in a mixture of water and the acetate of lead, the lead will be revived, and form an arbor Saturni. Oils dissolve the oxide of lead, and become thick and consistent; in which state they are used as the basis of plasters, cements for water-works, paints, &c. Sulphur readily dissolves lead in the dry way, and produces a brittle compound, of a deep grey colour and brilliant appearance, which is much less fusible than lead itself; a

property which is common to all the combinations of sulphur with the more fusible metals. The phosphoric acid, exposed to heat together with charcoal and lead, becomes converted into phosphorus, which combines with the metal. This combination does not greatly differ from ordinary lead; it is malleable, and easily cut with a knife; but it loses its brilliancy more speedily than pure lead, and when fused upon charcoal with the blowpipe, the phosphorus burns, and leaves the lead behind. Litharge fused with common salt decomposes it; the lead unites with the muriatic acid, and forms a yellow compound, used as a pigment. The same decomposition takes place in the humid way, if common salt be macerated with litharge; and the solution will contain caustic alkali. Lead unites with most of the metals. Gold and silver are dissolved by it in a slight red-heat. Both these metals are said to be rendered brittle by a small admixture of lead, though lead itself is rendered more ductile by a small quantity of them. Platina forms a brittle compound with lead; mercury amalgamates with it; but the lead is separated from the mercury by agitation, in the form of an impalpable black powder, oxygen being at the same time absorbed. Copper and lead do not unite but with a strong heat. If lead be heated so as to boil and smoke, it soon dissolves pieces of copper thrown into it; the mixture, when cold, is brittle. The union of these two metals is remarkably slight; for, upon exposing the mass to a heat no greater than that in which lead melts, the lead almost entirely runs off by itself. This process is called eliquation. The coarser sorts of lead, which owe their brittleness and granulated texture to an admixture of copper, throw it up to the surface on being melted by a small heat. Iron does not unite with lead, as long as both substances retain their metallic form. Tin unites very easily with this metal, and forms a compound, which is much more fusible than lead by itself, and is, for this reason, used as a solder for lead. Two parts of lead, and one of tin, form an alloy more fusible than either metal alone: this is the solder of the plumbers. Bismuth combines readily with lead, and affords a metal of a fine close grain, but very brittle. A mixture of eight parts bismuth, five lead, and three tin, will melt in a heat which is not sufficient to cause water to boil. Antimony forms a brittle alloy with lead. Nickel, cobalt, manganese, and zinc, do not unite with lead by fusion. All the oxides of lead are easily revived with heat and carbon. Oxygen and lead combine together in different proportions. If the nitrate of lead be dissolved in a precipitation produced by potash, the precipitate, when dried, will become the yellow protoxide. If it be somewhat vitrified, it constitutes litharge; and combined with carbonic acid, it becomes white lead, or ceruse. In this protoxide of lead, Berzelius found in 107·73 parts, 100 lead and 7·73 oxygen; from whence it is inferred, that the equivalent number of lead is 12·9366, or in round numbers 13. This protoxide forms the pigment massicot. Massicot exposed for about 48 hours to great heat, becomes red lead, or minium, and consists of 100 parts lead and 11·08 oxygen; and may be represented as two primes of lead and three of oxygen. By digesting red lead in nitric acid, the larger part is dissolved; but a dark brown powder remains insoluble, which is found to consist of 100 lead and 15·4 oxygen. Chloride of lead is formed by exposing the muriate to a moderate heat, or placing lead in chlorine. Iodide is formed by heating together the two constituents. Salts of lead have the peroxide for their base. They yield, when placed on charcoal by the blowpipe, a button of lead. They dissolve in water, and yield a colourless solution of an astringent sweetish taste. With ferro prussiate of potass they yield a white precipitate; with hydrosulphuret of potass, and sulphuretted hydrogen, a black precipitate; with gallic acid and infusion of galls, a white precipitate; with a plate of zinc, a white precipitate, or metallic lead. Lead alloyed with an equal weight of tin, ceases to be acted upon by vinegar. Acetate and subacetate of lead have a good effect, as external applications, for inflamed surfaces, burns, scrofulous sores, and as eyewashes. Lead taken internally is very injurious; hence, the diseases to which painters are liable. Litharge, dissolved in wines, to give them a sweet taste, is very mischievous. Sul-

phuretted hydrogen water will cause it to throw down a black precipitate.

LIGHT. Most of the properties of light belong to natural philosophy, and are accordingly left for our subsequent volume; but light has also properties which are strictly chemical, of which we here attempt a short account. It was discovered by sir William Herschel, that when light was refracted by the prism, and thereby separated into its seven primary component parts, these did not excite heat in an equa degree. He found that beginning at violet, the calorific power was least, and that it kept gradually increasing to the red, the other extremity of the prism, and did not even cease there, but was still greater even a little beyond it. The inference was, that there were calorific rays distinct from the rays producing vision, of which the spectrum extended beyond the visible ray. These very delicate experiments have been repeated by other philosophers, and to a great degree verified; and it may be laid down as clearly ascertained, that the calorific power of the rays in the spectrum increases from the violet to the red. It is also exceedingly probable, if not certain, that the calorific power goes beyond the illuminated space; but there is reason to believe that the maximum of heat is produced in the last rays of the red and not beyond the spectrum. These colorific rays follow the general laws by which undivided light is governed as to reflection and refraction. Whilst the chief calorific power is found at the red end of the spectrum, it is curious that at the other extremity the violet there is the chief chemical power in affecting the colours of substances exposed to it. If the lunar cornea, or muriate of silver, be moistened, and be exposed to the prismatic spectrum, no effect will be produced upon it if held in the space immediately beyond the red extremity; but if brought within the red ray, a small effect will be produced in making the muriate become black, and this power will be greater in going on through the orange, yellow, green, blue, and indigo, and will be found greatest of all in the violet; and its power does not there cease, but extends a little beyond it. Sir Humphrey Davy found, that a mixture of chlorine and hydrogen acted more rapidly upon each other, combining without explosion, when placed in the red ray, than when placed in the violet rays. The oxide of mercury formed from calomel and water of potass, when exposed to the spectrum, was not changed in the red rays, but when exposed to the violet, it became red, which must have arisen from the absorption of oxygen. Guiacum, exposed to the violet rays, passed rapidly from yellow to green. When a gaseous mixture of hydrogen and chlorine were exposed to the violet rays by Messrs. Lussac and Thenard, an explosion immediately took place. The light produced by coal and oil gas, and by olefiant gas, when concentrated ever so much, have not been found to produce any sensible degree of heat, or to occasion any change on the colour of muriate of silver, nor to affect a mixture of hydrogen and chlorine.

LIME. This abundant earth was thought to be a simple substance, until it was decomposed by Sir H. Davy, who found it to consist of oxygen and a metallic base, which he denominated calcium, under which article it is described. The metallic property is however only produced by the experimental chemist, and is very evanescent. It is with the oxide of calcium or lime, that we constantly meet, and its useful qualities render it a mineral of first importance The most important applications of lime are to agriculture and building: on which subjects sir H. Davy has given some excellent observations. Quicklime in its pure state, whether in powder, or dissolved in water, is injurious to plants. Grass is killed by watering it with lime water. But lime in its state of combination with carbonic acid, is a useful ingredient in soils. Calcareous earth is found in the ashes of the greater number of plants; and exposed to the air, lime cannot long continue caustic, but soon becomes united to carbonic acid. When lime, whether freshly burnt or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this kind of operation, lime renders matter which

was before comparatively inert, nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime. Mild lime, powdered limestone, marles, or chalks, have no action of this kind upon vegetable matter: by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matters. It is obvious from these circumstances, that the operation of quicklime, and marle or chalk, depends upon principles altogether different. Quicklime, in the act of becoming mild, prepares soluble out of insoluble matter. It is upon this circumstance that the operation of lime in the preparation for wheat crops depends; and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots or dry fibres, or inert vegetable matter. The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matter that it contains. The solution of the question, whether marle, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and ultimately by quicklime, which do not effervesce with acids; and sands more than clays. When a soil, deficient in calcareous matter, contains much soluble vegetable manure, the application of quicklime should always be avoided, as it either tends to decompose the soluble matters by uniting to their carbon and oxygen so as to become mild lime, or it combines with the soluble matters, and forms compounds having less attraction for water than the pure vegetable substance. The case is the same with respect to most animal manures; but the operation of the lime is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines likewise with the animal acids, and probably assists their decomposition by abstracting carbonaceous matter from them combined with oxygen; and consequently it must render them less nutritive. It tends to diminish likewise the nutritive powers of albumen from the same causes; and always destroys, to a certain extent, the efficacy of animal manures, either by combining with certain of their elements, or by giving to them new arrangements. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble. In those cases in which fermentation is useful to produce nutriment from vegetable substances, lime is always efficacious as with tanners bark. There are two modes in which lime acts as a cement: in its combination with water, and in its combination with carbonic acid. When quicklime is rapidly made into a paste with water, it soon loses its softness, and the water and the lime form together a solid coherent mass, which consists of 1 part of water to 3 parts of lime. When hydrate of lime, whilst it is consolidating, is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder, and more coherent than when lime alone is used; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and these bodies; and they render it less liable to decompose by the action of the carbonic acid in the air, and less soluble in water. The basis of all cements that are used for works that are to be covered with water, must be formed from hydrate of lime; and the lime made from impure limestones answers this purpose very well. Puzzolana is composed principally of silica, alumina, and oxide of iron; and it is used mixed with lime, to form cements intended to be employed under water. Mr. Smeaton, in the construction of the Eddystone light-house, used a cement composed of equal parts by weight of slacked lime and puzzolana. Puzzolana is a decomposed lava. Tarras, which was formerly imported in considerable quantities from Holland, is a mere decomposed basalt: two parts of slacked lime, and one part of tarras, form the principal part of the mortar used in the great dykes of Holland. Substances which will answer all the

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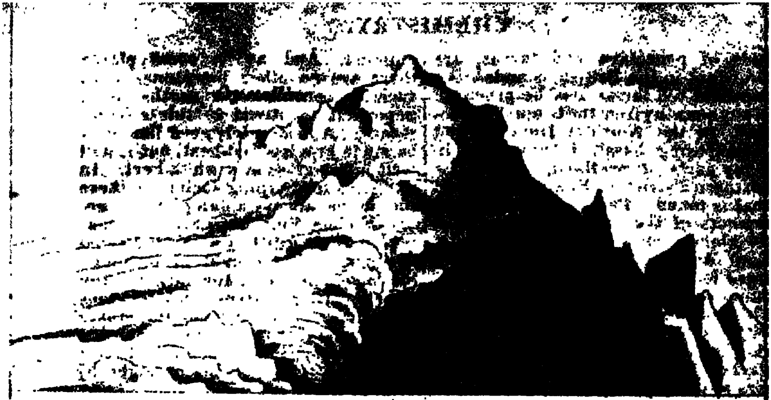
LIME. This abundant earth was thought to be a simple substance, until it was decomposed by Sir H. Davy, who found it to consist of oxygen and a metallic base, which he denominated calcium, under which article it is described. The metallic property is however only produced by the experimental chemist, and is very evanescent. It is with the oxide of calcium or lime, that we constantly meet, and its useful qualities render it a mineral of first importance The most important applications of lime are to agriculture and building: on which subjects sir H. Davy has given some excellent observations. Quicklime in its pure state, whether in powder, or dissolved in water, is injurious to plants. Grass is killed by watering it with lime water. But lime in its state of combination with carbonic acid, is a useful ingredient in soils. Calcareous earth is found in the ashes of the greater number of plants; and exposed to the air, lime cannot long continue caustic, but soon becomes united to carbonic acid. When lime, whether freshly burnt or slacked, is mixed with any moist fibrous vegetable matter, there is a strong action between the lime and the vegetable matter, and they form a kind of compost together, of which a part is usually soluble in water. By this kind of operation, lime renders matter which

was before comparatively inert, nutritive; and as charcoal and oxygen abound in all vegetable matters, it becomes at the same time converted into carbonate of lime. Mild lime, powdered limestone, marles, or chalks, have no action of this kind upon vegetable matter: by their action they prevent the too rapid decomposition of substances already dissolved; but they have no tendency to form soluble matters. It is obvious from these circumstances, that the operation of quicklime, and marle or chalk, depends upon principles altogether different. Quicklime, in the act of becoming mild, prepares soluble out of insoluble matter. It is upon this circumstance that the operation of lime in the preparation for wheat crops depends; and its efficacy in fertilizing peats, and in bringing into a state of cultivation all soils abounding in hard roots or dry fibres, or inert vegetable matter. The solution of the question, whether quicklime ought to be applied to a soil, depends upon the quantity of inert vegetable matter that it contains. The solution of the question, whether marle, mild lime, or powdered limestone, ought to be applied, depends upon the quantity of calcareous matter already in the soil. All soils are improved by mild lime, and ultimately by quicklime, which do not effervesce with acids; and sands more than clays. When a soil, deficient in calcareous matter, contains much soluble vegetable manure, the application of quicklime should always be avoided, as it either tends to decompose the soluble matters by uniting to their carbon and oxygen so as to become mild lime, or it combines with the soluble matters, and forms compounds having less attraction for water than the pure vegetable substance. The case is the same with respect to most animal manures; but the operation of the lime is different in different cases, and depends upon the nature of the animal matter. Lime forms a kind of insoluble soap with oily matters, and then gradually decomposes them by separating from them oxygen and carbon. It combines likewise with the animal acids, and probably assists their decomposition by abstracting carbonaceous matter from them combined with oxygen; and consequently it must render them less nutritive. It tends to diminish likewise the nutritive powers of albumen from the same causes; and always destroys, to a certain extent, the efficacy of animal manures, either by combining with certain of their elements, or by giving to them new arrangements. Lime should never be applied with animal manures, unless they are too rich, or for the purpose of preventing noxious effluvia. It is injurious when mixed with any common dung, and tends to render the extractive matter insoluble. In those cases in which fermentation is useful to produce nutriment from vegetable substances, lime is always efficacious as with tanners bark. There are two modes in which lime acts as a cement: in its combination with water, and in its combination with carbonic acid. When quicklime is rapidly made into a paste with water, it soon loses its softness, and the water and the lime form together a solid coherent mass, which consists of 1 part of water to 3 parts of lime. When hydrate of lime, whilst it is consolidating, is mixed with red oxide of iron, alumina, or silica, the mixture becomes harder, and more coherent than when lime alone is used; and it appears that this is owing to a certain degree of chemical attraction between hydrate of lime and these bodies; and they render it less liable to decompose by the action of the carbonic acid in the air, and less soluble in water. The basis of all cements that are used for works that are to be covered with water, must be formed from hydrate of lime; and the lime made from impure limestones answers this purpose very well. Puzzolana is composed principally of silica, alumina, and oxide of iron; and it is used mixed with lime, to form cements intended to be employed under water. Mr. Smeaton, in the construction of the Eddystone light-house, used a cement composed of equal parts by weight of slacked lime and puzzolana. Puzzolana is a decomposed lava. Tarras, which was formerly imported in considerable quantities from Holland, is a mere decomposed basalt: two parts of slacked lime, and one part of tarras, form the principal part of the mortar used in the great dykes of Holland. Substances which will answer all the

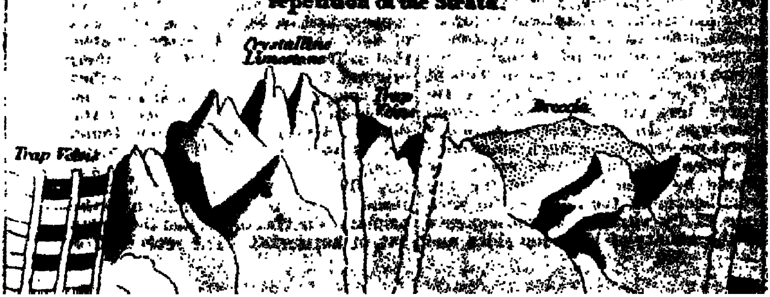
ends of puzzolana and tarras, are abundant in the British islands. An excellent red tarras may be procured in any quantity from the Giants' Causeway, in the North of Ireland; and decomposing basalt is abundant in many parts of Scotland, and in the northern districts of England in which coal is found. Parker's cement, and cements of the same kind made at the alum works of Lord Dundas and Lord Mulgrave, are mixtures of calcined ferruginous, silicious, and aluminous matter, with hydrate of lime. The cements which act by combining with carbonic acid, or the common mortars, are made by mixing together slacked lime and sand These mortars at first solidify as hydrates, and are slowly converted into carbonate of lime by the action of the carbonic acid of the air. Mr. Tennant found that a mortar of this kind, in three years and a quarter, had regained 63 per cent. of the quantity of carbonic acid gas, which constitutes the definite proportion in carbonate of lime. The rubbish of mortar from houses owes its power to benefit lands principally to the carbonate of lime it contains, and the sand in it: and its state of cohesion renders it particularly fitted to improve clayey soils. The hardness of the mortar in very old buildings, depends upon the perfect conversion of all its parts into carbonate of lime. The purest limestones are the best adapted for making this kind of mortar; the magnesian limestones make excellent water cements, but act with too little energy upon carbonic acid gas, to make good common mortar. The Romans, according to Pliny, made their best mortar a year before it was used, so that it was partially combined with carbonic acid gas before it was employed. In burning lime there are some particular precautions required for the different kinds of limestones. In general, one bushel of coal is sufficient to make four or five bushels of lime. The magnesian limestone requires less fuel than the common limestone. In all cases in which a limestone containing much aluminous or siliceous earth is burnt, great care should be taken to prevent the fire from becoming too intense; for such lime easily vitrifies, in consequence of the affinity of lime for silica and alumina. And as in some places there are no other limestones than such as contain other earths, it is important to attend to this circumstance. A moderately good lime may be made at a low red-heat, but it will melt into a glass at a white-heat. In limekilns for burning such lime, there should be always a damper. In general, when limestones are not magnesian, their purity will be indicated by their loss of weight in burning; the more they lose, the larger is the quantity of calcareous matter they contain. The magnesian limestones contain more carbonic acid than the common limestones; and all of them lose more than half their weight by calcination.

LIMESTONE. Under this denomination, naturalists class not only what is commonly called limestone, but also those finer species usually denominated marbles. The constituent parts are the same. That granular limestone is primitive, has been long allowed. Among many other remarkable mountains of this stone, the stupendous heights of Fintter-Aar-Horn, Yungfraw-Horn, and Shreck-Horn, or the Peak of Horror, in Swisserland, deserve especial commemoration. Saussure has long since observed, that it often presents lofty spires, like granite; and being a manifest deposition, must evince that granite is so likewise. It appears between layers of mica slate and gneiss, as schistose, sederite, and alternate with common slate. Primitive limestone is commonly white, dark iron-grey, or reddish brown, and is not always granular, being sometimes compact. It sometimes supplies the place of quartz in mica slate, and sometimes of felspar in granitoid, and a rock of the gneiss structure. It is rarely metalliferous, but in Siberia it presents rich mines of copper, and in South America, veins of gold and silver. It is remarkable, that in limestone the shells retain their original form, while in clay slate they are compressed—a circumstance ascribed to the great subsidence of the latter. Caverns are seldom found except in limestone, the rock being commonly eroded by a stream of water. The Wernerians regard limestone as of three formations—the primary, the transitive, and the floetz flat, or horizontal. The second often



Change of the common to the crystalline Limestone in the direction of the Strata.

Change of the common to the crystalline Limestone according to the repetition of the Strata.



contains coralites and madrepores; but Faujas showed a madrepore in Carrara marble, which is esteemed primitive. In granular limestone the characters mostly correspond with those of marble; but the mode of combination must vary, as it is not capable of so fine a polish. Primitive granular limestone is often interspersed with mica, and sometimes with orbicular crystals of quartz. There is a species of limestone which has been called pisolite, from its appearance resembling conglomerated peas, and is chiefly brought from Carlsbad in Bohemia, where it constitutes a large bed. It is of a yellowish white, and the imaginary peas are in elegant concentric layers of white and brown, formed around a grain of sand, like pearls in the shell. Cronstedt has with some propriety ranked it among the sinters or depositions. There is another kind of limestone called sinapite, from its resembling mustard-seed; others call it meconite, from its resembling poppy seeds; but a more usual denomination is oolite, from the eggs or roe of fish. The kettonstone of Rutlandshire and the bathstone is of this sort. Shells of almost every sort, and zoophytes and mollusca abound in common limestones. The substances called *alabastrum* and *alabastrites* by the ancients, are well known to be merely calcareous, as they effervesce with nitrous acid; whereas the moderns have applied the name of alabaster to quite a distinct substance, impregnated with the sulphuric acid, so that the nitrous can produce no effect. The alabastrite of the ancients is a mere deposition from the superincumbent calcareous rocks. It was much used for boxes to hold ointment, as we learn from Pliny and the New Testament. There is a species of stone much used in architecture of a character which may be considered as intermediate between limestone and marble. It has been denominated konite, and appears to have been the freestone of the middle ages, and called ashler when only roughly hewn. It is not to be confounded with quite a different kind of stone also called freestone by some writers, which is sandstone, consisting chiefly of siliceous earth. Konite is merely a compact limestone of an earthy texture, sometimes coarse and sometimes fine. There is sometimes a slight admixture of silex, often of argil, rarely of magnesia, which however has been found by chemical analysis in some kinds, as those employed on Westminster abbey and the cathedral of York, and that fine earth must of course impart some of its usual qualities of unctuous softness and durability. By some little research it might probably be discovered from what quarter the stone used in our cathedrals and other ancient buildings was procured. At present, the most remarkable konite used in the south of England is that of Portland, which is thus described by Dr. Woodward: "Stone out of the great quarry of Portland, of a pale or whitish colour, composed of numerous small rounded grains, not unlike the smaller ova of fishes. They split in the cutting of the stone, so that it is capable of being brought to a surface, very smooth and equal. Besides this, and all sorts of stone that are composed of granules, will cut and rive in any direction, as well in a perpendicular or in a diagonal as horizontally and parallel to the site of the strata. It is for this reason that they have obtained the name of freestone. Then these bear the injuries of the weather equally and indifferently in all positions; whereas all the stone that is slaty, with a texture long and parallel to the site of the stratum, will split only lengthways or horizontally; or if it be placed in any other position, is apt to give way, start, and burst when any great weight is laid upon it; which inconvenience the Portland stone is not liable to. The building stone chiefly used at Edinburgh, especially in the beautiful new city, is from the quarry of Craigleith, and is an argilaceous limestone with blackish veins. The ancient Romans, whose buildings are alike distinguished by magnificence and durability, chiefly like their successors, employed the travertino, which abounds on the banks of the Anid, and is reproduced by its depositions. To the lasting nature of this stone, and of the mortar mixed with puzzolana, which also abounds in the neighbourhood, that is, to circumstances merely accidental may the preservation of the common sewers and other works

of surprising antiquity be ascribed. But the use of konite in building ascends even to the earliest ages, the pyramids of Egypt being constructed with this material, which seems to be the lapis troicus of the ancients. The Egyptian konite, which forms a whole chain of mountains extending from Cairo and the front of the pyramids far to the south, is sometimes simple, and sometimes contains shells, chiefly nummulites, which, when cut across, resemble grains of wheat or barley, whence the fable of the ancients, that the workmen employed received such vast quantities of grain, that much of it was left and petrified. Some of the most ancient edifices of Persia, Greece and Italy are also built with konite; but the ruins of Pæstum, and the temple of Agrigentum are of calcareous tufa.—For an account of the different kinds of marble, see *Marble*.

LIQUEFACTION, the act of rendering liquid, which may be done by fusion, as in melting lead; by deliquescence as in melting salts; or by solution, as of zinc in sulphuric acid.

LIQUIDITY. The circumstance of being liquid.

LIQUOR OF FLINTS, is the solution of siliceous in alkaline solutions.

LITHIA.—A new alkali has been discovered in a mineral lately found in the mine of Uten, in Sweden. This mineral consists of 80 parts of silex, 17 of alumine, and 3 of the new alkali. It is said that spodumene contains 8 per cent of it, as does another mineral from Uten, called crystallized lepidolite, which also contains boracic acid, silex and alumine. This alkali is distinguished by Berzelius from the old ones: 1. By the fusibility of its salts; the liquefaction of its sulphate and muriate before they arrive at a red heat, and of the carbonate at the moment when it begins to become red: 2. By its muriate, which is deliquescent, like the muriate of lime: 3. By its carbonate, which does not readily dissolve in water; but to which it communicates precisely the same taste as the other alkalies: the carbonate when raised to a red heat in a platinum crucible, attacks the platinum as if nitrate of soda or potass had been employed: 4. By its great capability of saturating acids.

LITHIA, (CAUSTIC) has a very sharp burning taste, and destroys the cuticle of the tongue like potass. It is not very readily soluble in water, and hot water has no greater power than cold water. Exposed to the air, it attracts carbonic acid, but not moisture; it unites with sulphur; with the acids it forms various salts, as sulphate and bisulphate of lithia; phosphate and biphosphate of lithia; nitrate, carbonate, chromate, oxalate tartrate, acetate of lithia. There are also the double salts of tartrate of lithia and potass, and tartrate of lithia and soda. It will not form a double salt with muriate of platinum, and this distinguishes lithia from potass. Lithia has been found to be like the other alkalies, a compound of oxygen and a metallic basis. This basis has been called lithium. According to Gmelin, lithia consists of lithium 58·65, and oxygen, 41·95.

LITHIC ACID. This was discovered about the year 1776 by Scheele, in analyzing human calculi, of many of which it constitutes the greater part, and of some, particularly that which resembles wood in appearance, it forms almost the whole. It is likewise present in human urine, and in that of the camel; and Dr. Pearson found it in those arthritic concretions commonly called chalkstones, which Mr. Tennant has since confirmed. It is often called *uric* acid. The following are the results of Scheele's experiments on calculi, which were found to consist almost wholly of this acid: 1. Diluted sulphuric acid produced no effect on the calculus, but the concentrated dissolved it; and the solution distilled to dryness left a black coal, giving off sulphurous acid fumes. 2. The muriatic acid, either diluted or concentrated, had no effect on it, even with ebullition. 3. Dilute nitric acid attacked it cold; and with the assistance of heat produced an effervescence and red vapour, carbonic acid was evolved, and the calculus was entirely dissolved. The solution was acid, even when saturated with the calculus, and gave a beautiful red colour to the skin in half an hour after it was applied; when evaporated, it became of a blood red, but the colour was destroyed by adding a drop of acid; it did not precipitate muriate of barytes, or metallic solutions, even with the addition of an alkali; alkalis rendered it more yellow, and, if superabundant, changed

it by a strong digesting heat to a rose colour; and this mixture imparts a similar colour to the skin, and is capable of precipitating sulphate of iron black, sulphate of copper green, nitrate of silver grey, super-oxygenated muriate of mercury, and solutions of lead and zinc, white. Lime-water produced in the nitric solution a white precipitate, which dissolved in the nitric and muriatic acids without effervescence, and without destroying their acidity. Oxalic acid did not precipitate it. 4. Carbonate of potash did not dissolve it, either cold or hot, but a solution of perfectly pure potash dissolved it even cold. The solution was yellow; sweetish to the taste; precipitated by all the acids, even the carbonic; did not render lime-water turbid; decomposed and precipitated solution of iron brown, of copper grey, of silver black, of zinc, mercury, and lead, white; and exhaled a smell of ammonia. 5. About 200 parts of lime-water dissolved the calculus by digestion, and lost its acrid taste. The solution was partly precipitated by acids. 6. Pure water dissolved it entirely, but it was necessary to boil for some time 360 parts with one of the calculus in powder. This solution reddened tincture of litmus, did not render lime-water turbid, and on cooling deposited in small crystals almost the whole of what it had taken up. 7. Seventy-two grains distilled in a small glass retort over an open fire, and gradually brought to a red heat, produced water of ammonia mixed with a little animal oil, and a brown sublimate weighing 28 grains and 12 grains of coal remained, which preserved its black colour on red hot iron in the open air. The brown sublimate was rendered white by a second sublimation; was destitute of smell, even when moistened by an alkali; was acid to the taste; dissolved in boiling water, and also in alcohol, but in less quantity; did not precipitate lime-water; and appeared to resemble succinic acid. Fourcroy has found, that this acid is almost entirely soluble in 2000 times its weight of cold water, when the powder is repeatedly treated with it. From his experiments he infers, that it contains azote, with a considerable portion of carbon, and but little hydrogen, and little oxygen. Of its combinations with the bases we know but little. The lithate of lime is more soluble than the acid itself; but on exposure to the air it is soon decomposed, the carbonic acid in the atmosphere combining with the lime, and precipitating both the lithic acid and new formed carbonate of lime separate from each other. The lithate of soda appears from the analysis of Mr. Tennant to constitute the chief part of the concretions formed in the joints of gouty persons. The lithate of potash is obtained by digesting calculi in caustic lixivium; and Fourcroy recommends the precipitation of the lithic acid from this solution by acetic acid, as a good process for obtaining the acid pure in small, white, shining, and almost pulverulent needles. It reddens the infusion of litmus. The dry acid is not acted on nor dissolved by the alkaline carbonates, or subcarbonates. It decomposes soap when assisted by heat; as it does also the alkaline sulphurets and hydrosulphurets. No acid acts on it, except those that occasion its decomposition. It dissolves in hot solutions of potash and soda, and likewise in ammonia, but less readily. The lithates are all tasteless, and resemble in appearance lithic acid itself. They are sparingly soluble; are decomposed by a red heat, which destroys the acid. The lithic acid is precipitated from these salts, by all the acids except the prussic and carbonic.

LITMUS.—See *Archil*.

LIVER OF SULPHUR.—See *Sulphur*.

LIXIVIATION. The application of water to the fixed residues of bodies, for the purpose of extracting the saline part.

LIXIVIUM. A solution obtained by lixiviation.

LOADSTONE.—See *Ores of Iron*.

LOAM.—See *Clay*.

LOGWOOD. The tree which yields it is called by Linnæus, hæmatoxylum campechianum. Logwood is so heavy as to sink in water; hard, compact, of a fine grain, capable of being polished, and scarcely susceptible of decay. Its predominant colour is red, tinged with orange, yellow, and black. It yields its colour, both to spirituous and watery menstrua. Alcohol extracts it more readily and copiously than water. The colour of its dyes is a fine red, inclining a little to violet

or purple, which is principally observable in its watery decoction. This, left to itself, becomes in time yellowish, and at length black. Acids turn it yellow; alkalis deepen its colour, and give it a purple or violet hue. Stuffs would take only a slight and fading colour from decoction of logwood, if they were not previously prepared with alum and tartar. A little alum is added also to the bath. By these means they acquire a pretty good violet. A blue colour may be obtained from logwood, by mixing verdegris with the bath, and dipping the cloth till it has acquired the proper shade. The great consumption of logwood is for blacks, to which it gives a lustre and velvety cast, and for greys of certain shades. It is also of very extensive use for different compound colours, which it would be difficult to obtain of equal beauty and variety, by means of drugs affording a more permanent dye. Juice of logwood is frequently mixed with that of brasil, to render colours deeper; their proportion being varied according to the shade desired. Logwood is used for dyeing silk, violet. For this, the silk must be scoured, alumed, and washed; because, without aluming, it would take only a reddish tinge, that would not stand wetting. To dye silks thus, it must be turned in a cold decoction of logwood, till it has acquired the proper colour: if the decoction were used hot, the colour would be in stripes and uneven. Bergman has already observed, that a fine violet might be produced from logwood, by impregnating the silk with solution of tin. In fact, we may thus obtain, particularly by mixing logwood and brasil in various proportions, a great number of fine shades, more or less inclined to red, from lilac to violet.—See *Hematin*.

LOMONITE, or LAUMONITE. Di-prismatic Zeolite.

LUMACHELLA.—See *Limestone*.

LUNA CORNEA. Muriate of silver.—See *Silver*.

LUNAR CAUSTIC. Nitrate of silver, fused in a low heat.—See *Silver*.

LUTE. The lutes with which the joinings of vessels are closed, are of different kinds, according to the nature of the operations to be made, and of the substances to be distilled in these vessels. When vapours of watery liquors, and such as are not corrosive, are to be contained, it is sufficient to surround the joining of the receiver to the nose of the alembic, or of the retort, with slips of paper or of linen, covered with flour-paste. In such cases also slips of wet bladder are very conveniently used. When more penetrating and dissolving vapours are to be contained, a lute is to be employed of quicklime slacked in the air, and beaten into a liquid paste with whites of eggs. This paste is to be spread upon linen slips, which are to be applied exactly to the joining of the vessels. This lute is very convenient, easily dries, becomes solid, and sufficiently firm. Of this lute, vessels may be formed hard enough to bear polishing on the wheel. Lastly, when acid and corrosive vapours are to be contained, we must then have recourse to the lute called fat lute. This lute is made by forming into a paste some dried clay finely powdered, sifted through a silken searce, and moistened with water, and then by beating this paste well in a mortar with boiled linseed oil, that is, oil which has been rendered drying by litharge dissolved in it, and fit for the use of painters. This lute easily takes and retains the form given to it. It is generally rolled into cylinders of a convenient size. These are to be applied, by flattening them, to the joinings of the vessels, which ought to be perfectly dry, because the least moisture would prevent the lute from adhering. When the joinings are well closed with this fat lute, the whole is to be covered with slips of linen spread with lute of lime and whites of eggs. These slips are to be fastened with packthread. The second lute is necessary to keep on the fat lute, because this latter remains soft, and does not become solid enough to stick on alone. Fine porcelain clay, mixed with a solution of borax, is well adapted to iron vessels, the part received into an aperture being smeared with it.

LYCOPODIUM. The fine dust of lycopodium, or clubmoss, is properly the seeds of the plant, and when diffused or strewed in the air, it takes fire from a candle, and burns off like

a flash of lightning It is used in the London theatres.

LYDIAN STONE. Flinty slate.

LYTHRODES.—*See Scapolite.*

M.

MACERATION. The steeping of a body in cold liquor.

MADDER, a substance very extensively employed in dyeing, is the root of the rubia tinctorum. Although madder will grow both in a stiff clayey soil, and in sand, it succeeds better in a moderately rich, soft, and somewhat sandy soil: it is cultivated in many of the provinces of France, in Alsace, Normandy, and Provence: the best of European growth is that which comes from Zealand. The best roots are about the thickness of a goose-quill, or, at most, of the little finger: they are semi-transparent, and of a reddish colour, they have a strong smell, and the bark is smooth. Hellot ascribes the superiority of the madder which comes from the Levant to the circumstance of its having been dried in the open air. The red colouring matter of madder may be dissolved in alcohol, and on evaporation a residuum of a deep red is left. Fixed alkali forms in this solution a violet, the sulphuric acid a fawn-coloured, and the sulphate of potash a fine red precipitate. Precipitates of various shades may be obtained by alum, nitre, chalk, sugar of lead, and the muriate of tin. The quantity of aqueous chlorine required to destroy the colour of a decoction of madder, is double what is necessary to destroy that of a decoction of an equal weight of brasil wood. Wool would receive from madder only a perishable dye, if the colouring particles were not fixed by a base, which occasions them to combine with the stuff more intimately, and which in some measure defends them from the destructive influence of the air. For this purpose, the woollen stuffs are first boiled for two or three hours with alum and tartar, after which they are left to drain; they are then slightly wrung, and put into a linen bag, and carried into a cool place, where they are suffered to remain for some days. The quantities of alum and tartar, as well as their proportions, vary much in different manufactories. Hellot recommends five ounces of alum and one ounce of tartar to each pound of wool; if the proportion of tartar be increased to a certain degree, instead of a red, a deep and durable cinnamon colour is produced, because, as we have seen, acids have a tendency to give a yellow tinge to the colouring particles of madder. Berthollet found, that by employing one half tartar, the colour sensibly bordered more on the cinnamon than when the proportion was only one-fourth of the alum. In dyeing with madder, the bath must not be permitted to boil, because that degree of heat would dissolve the fawn-coloured particles,* which are less soluble than the red, and the colour would be different from that which we wish to obtain. The quantity of madder which Mr. Poerner employs is only one-third of the weight of the wool, and Schaeffer advises only one-fourth. If wool be boiled for two hours with one-fourth of sulphate of iron, then washed, and afterwards put into cold water with one-fourth of madder, and then boiled for an hour, a coffee colour is produced. Bergman adds, that if the wool have not been soaked, and if it be dyed with one part of sulphate of iron and two of madder, the brown obtained borders upon a red. Berthollet employed a solution of tin in various ways, both in the preparation and in the maddering of cloth. He used different solutions of tin, and found that the tint was always more yellow or fawn-coloured, though sometimes brighter than that obtained by the common process. Mr. Guhliche describes a process for dyeing silk with madder. For one pound of silk he orders a bath of four ounces of alum, and one ounce of a solution of tin; the liquor is to be left to settle, when it is to be decanted, and the silk carefully soaked in it, and left for twelve hours; and after this preparation, it is to be immersed in a bath containing half a pound of madder softened by boiling with an infusion of galls in white wine; this bath is to be kept moderately hot for an hour, after which it is to be made to

boil for two minutes. When taken from the bath, the silk is to be washed in a stream of water, and dried in the sun. Mr. Gubliche compares the colour thus obtained, which is very permanent, to the Turkey red. If the galls be left out the colour is clearer. A g eat degree of brightness may be communicated to the first of these, by afterwards passing it through a bath of brasil wood, to which one ounce of solution of tin has been added: the colour thus obtained, he says, is very beautiful and durable. The madder red of cotton is distinguished into two kinds: one is called simple madder red; the other, which is much brighter, is called Turkey, or Adrianople red, because it comes from the Levant, and has seldom been equalled in brightness or durability by our artists. Galls, or sumach, dispose thread and cotton to receive the madder colour, and the proper mordant is acetate of alumina. The nitrate and muriate of iron, as a mordant, produces a better effect than the sulphate and acetate of the same metal; they afford a beautiful well saturated violet colour. The Adrianople red possesses a degree of brightness which it is difficult for us to approach by any of the processes hitherto mentioned.

MADREPORE, a species of coral, consisting of carbonate of lime, and a little animal membraneous substance.

MAGISTERY. Chemists formerly applied this term to almost all precipitates; at present it is applied only to a few, which have retained the name from habitual usage.

MAGNESIA, was considered as one of the primitive earths, and has been found by Sir H. Davy to consist of oxygen, and a metallic basis called magnesium. It has been found native, combined with water. To procure pure magnesia, dissolve any quantity of the sulphate of magnesia, and add to the solution subcarbonate of potass, and the magnesia will be precipitated. Boil this precipitate with distilled water, dry it, and expose in a crucible, to a red heat. In commerce, magnesia is usually obtained by acting on magnesian limestone with the bittern of the salt manufactories, which is left behind after the common salt is abstracted. The muriatic acid unites with the lime, and forms a soluble salt, whilst the magnesia is left behind. Another mode is to decompose the bittern, by adding the subcarbonate of ammonia, obtained from the distillation of bones in iron cylinders. Muriate of ammonia, and subcarbonate of magnesia, result. If the former be mixed with lime and sublimed, the subcarbonate of ammonia is recovered, and may again be mixed with other bittern, to obtain more magnesia. Magnesia is a white powder, soft to the touch. Its specific gravity is 2·3. It has an alkaline effect on infusion of violets, rendering it green. It is very infusible, but yields to the heat of the hydroxygen blow pipe. It has very little taste or smell. It absorbs water, but is almost insoluble in that fluid. When precipitated by a caustic alkali from the sulphate, it forms a hydrate; but the water may be separated by a red heat. When magnesia is exposed to the air, it attracts carbonic acid. The magnesia of the shops, most usually sold, is the carbonate of magnesia, which is mild; by exposure to heat, the carbonic acid is separated, and the magnesia will be found to have lost half its weight, and to have become caustic. In medicine, magnesia is given as an anti-acid, and as a purgative also, with a view to mitigate or cure the stone in the bladder. Caution ought to be used not to administer too large quantities, and for too great a length of time, as cases have occurred where it has formed concretions in the bowels. The metallic basis is obtained by electricity, in the same manner as barium. When magnesia is strongly heated with two volumes of chlorine, one volume of oxygen is disengaged, and the chloride is absorbed. The salt called muriate of magnesia is a chlorine combined with water.

MAGNESIA (Hydrate of). This mineral, consisting of pure magnesia and water, was found by Dr. Bruce of New York, in New Jersey. Its constituents are 70 magnesia, 30 water.

MAGNESIAN LIMESTONE. The constituents of this mineral are given under the article *Dolomite.* It had been long known to farmers in the neighbourhood of Doncaster, that lime made from a certain limestone

applied to the land, often injured the crops considerably. Mr. Tennant, in making a series of ex eriments upon this peculiar calcareous substance, found that it contained magnesia; and on mixing some calcined magnesia with soil, in which he sowed different seeds, he found that they either died, or vegetated in a very imperfect manner, and the plants were never healthy. And with great justice and ingenuity he referred the bad effects of the peculiar limestone to the magnesian earth it contains. In making some inquiries concerning this subject, Sir H. Davy found, that there were cases in which this magnesian limestone was used with good effect. Amongst some specimens of limestone which Lord Somerville put in to his hands, two marked as peculiarly good, proved to be magnesian limestones. And lime made from the Breedon limestone is used in Leicestershire, where it is called hot lime; and it is stated by farmers in the neighbourhood of the quarry, that they employ it advantageously in small quantities, seldom more than 25 or 30 bushels to the acre; and that they find it may be used with good effect in larger quantities, upon rich land. A minute chemical consideration of this question will lead to its solution. Magnesia has a much weaker attraction for carbonic acid than lime, and will remain in the state of caustic or calcined magnesia for many months, though exposed to the air. And as long as any caustic lime remains, the magnesia cannot be combined with carbonic acid, for lime instantly attracts carbonic acid from magnesia. When a magnesian limestone is burnt, the magnesia is deprived of carbonic acid much sooner than the lime; and if there is not much vegetable or animal matter in the soil to supply, by its decomposition, carbonic acid, the magnesia will remain for a long while in the caustic state, and in this state acts as a poison to certain vegetables. And that more magnesian lime may be used upon rich soils, seems to be owing to the circumstance, that the decomposition of the manure in them, supplies carbonic acid. And magnesia in its mild state, i. e. fully combined with carbonic acid, seems to be always an useful constituent of soils. Carbonate of magnesia, (procured by boiling the solution of magnesia in supercarbonate of potassa) has been thrown upon grass, and upon growing wheat and barley, so as to render the surface white; but the vegetation was not injured in the slightest degree. And one of the most fertile parts of Cornwall—the Lizard, is a district in which the soil contains mild magnesian earth. The Lizard Downs bear a short and green grass, which feeds sheep, producing excellent mutton; and the cultivated parts are amongst the best corn lands in the county. Lime from the magnesian limestone may be applied in large quantities to peats; and where lands have been injured by the application of too large a quantity of magnesian lime, peat will be a proper and efficient remedy. Magnesian limestones effervesce little when plunged into an acid. A simple test of magnesia in a limestone is this circumstance, and its rendering diluted nitric acid or aquafortis milky. From the analysis of Mr. Tennant, it appears that the magnesian limestones contain from

20·3 to 22·5 magnesia
29·5 to 31·7 lime
47·2 carbonic acid
0·8 clay and oxide of iron.

Magnesian limestones are usually coloured brown or pale yellow. They are found in Somersetshire, Leicestershire, Derbyshire, Shropshire, Durham, and Yorkshire. I have never met with any in other counties in England, but they abound in many parts of Ireland, particularly near Belfast.

MAGNESITE. Colour yellowish-gray, or yellowish-white, and marked with spots. Rather easily frangible. Sp. gr. 2·881. Its constituents are, 46 magnesia, 51 carbonic acid, 1 alumina, 0·25 ferruginous manganese, 0·16 lime, 1 water. It is found at Hrubschitz in Moravia, in serpentine rocks.

MALACHITE, an ore of copper.

MALACOLITE. Sablite.

MALATES and MALIC ACID. See *Sorbic Acid*.

MALLEABILITY. The property of a metal, by which it may be hammered into broad plates.

MALTHA. A mineral tallow, said to have been found on the coast of Finland. It is like wax; its specific gravity is 0·77.

MANGANESE. This metal is not only an object of interest in the speculations of the experimental chemist · but it is of the utmost use in manufactures, from its being employed to furnish the chlorine gas, which is so effectual in bleaching. It is a metal of a dull whitish colour when broken, but which soon grows dark by oxidation, from the action of the air. It is hard, brittle, though not pulverizable, and rough in its fracture; so difficultly fusible, that no heat yet exhibited has caused it to run into masses of any considerable magnitude. Its sp. gr. is 8·0. When broken in pieces it falls into a powder by spontaneous oxidation. Concentrated sulphuric acid attacks manganese, at the same time that hydrogen gas is disengaged. If sulphuric acid be added, and drawn off by distillation several times from the black oxide, by a heat nearly approaching to ignition, in a glass vessel, it is found, that oxygen gas is disengaged toward the end of each process, and part of the oxide is dissolved. The solution of the sulphate made from the metal itself is colourless. If it be made from the black oxide, it is a purplish-red; but this colour is destroyed by the light of the sun, and again restored by removing the solution into the dark. Sulphurous acid dissolves the oxide, taking part of its oxygen, which converts it into sulphuric acid, and thus forming a sulphate with the remaining oxide. Nitric acid dissolves manganese with effervescence, and the escape of nitrous gas. A spongy, black, and friable matter remains, which is a carburet of iron. The solution does not afford crystals. The oxide is more readily soluble in nitrous acid. Manganese is dissolved in the usual manner by muriatic acid. The solution of manganese in muriatic acid scarcely affords crystals; but a deliquescent saline mass by evaporation which is soluble in alcohol. In the dry way, the oxide of manganese combines with such earths and saline substances as are capable of undergoing fusion in a strong heat. These experiments are most advantageously performed by the blow-pipe,—which see. This metal melts readily with most of the other metals, but rejects mercury. Gold and iron are rendered more fusible by a due addition of manganese; and the latter metal is rendered more ductile. Copper becomes less fusible, and is rendered whiter, but of a colour subject to tarnish. The ore of manganese, which is known in Derbyshire by the name of *black wadd*, is remarkable for its spontaneous inflammation with oil. It is of a dark brown colour, of a friable earthy appearance, partly in powder, and partly in lumps. If half a pound of this be dried before a fire, and afterward suffered to cool for about an hour; and it be then loosely mixed or kneaded with two ounces of linseed oil; the whole, in something more than half an hour, becomes gradually hot, and at length bursts into flame. This effect wants explanation. It seems, in some measure, to resemble the inflammation of oils by the nitric acid. Manganese was used chiefly by glass makers and potters; but the important discovery of chlorine has greatly extended its utility. Chemists differ in the number of oxides of manganese. Sir H. Davy says, there are two, some say three others four, others five. Sir H. Davy's first oxide is the black oxide; the second is the olive oxide, which becomes green by the action of potass.

MANNA. Several vegetables afford manna; but the ash, the larch, and the alhagi, afford it in the largest quantities. The ash which affords manna grows naturally in all temperate climates, but Calabria and Sicily appear to be the most natural countries to this tree. The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer. Its smell is strong, and its taste sweetish and slightly nauseous; if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal. Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar. Manna affords, by distillation, water, acid, oil, and ammonia: its coal affords fixed alkali. This substance forms the basis of many purgative medicines.

MANURES. Vegetable or animal

substances introduced into the soil for the purpose of accelerating vegetation, and producing an increase of crop. The manner in which they produce this effect has been best explained by sir H. Davy in his Lectures on Agricultural Chemistry. The pores in the fibres of the roots of plants are so small, that it is with difficulty they can be discovered by the microscope; it is not therefore probable, that solid substances can pass into them from the soil. Sir H. Davy tried an experiment on this subject: some impalpable powdered charcoal procured by washing gunpowder was placed in a phial containing pure water, in which a plant of peppermint was growing: the roots of the plant were pretty generally in contact with the charcoal. The experiment was made in the beginning of May, 1805; the growth of the plant was very vigorous during a fortnight, when it was taken out of the phial: the roots were cut through in different parts; but no carbonaceous matter could be discovered in them, nor were the smallest fibrils blackened by charcoal, though this must have been the case had the charcoal been absorbed in a solid form. No substance is more necessary to plants than carbonaceous matter; and if this cannot be introduced into the organs of plants except in a state of solution, there is every reason to suppose that other substances less essential will be in the same case. Sir H. Davy found by some experiments made in 1804, that plants introduced into strong fresh solutions of sugar, mucilage, tanning principle, jelly, and other substances died; but that plants lived in the same solutions after they had fermented. At that time, he supposed that fermentation was necessary to prepare the food of plants; but he afterwards found that the deleterious effect of the recent vegetable solutions was owing to their being too concentrated; in consequence of which the vegetable organs were probably clogged with solid matter, and the transpiration by the leaves prevented. In the beginning of June, in the next year, he used solutions of the same substances, but so much diluted, that there was only about $\frac{1}{200}$ part of solid vegetable or animal matter in these solutions. Plants of mint grew luxuriantly in all these solutions; but least so in that of the astringent matter. He watered some spots of grass in a garden with the different solutions separately, and a spot with common water: the grass watered with solutions of jelly, sugar, and mucilage grew most vigorously; and that watered with the solution of the tanning principle grew better than that watered with common water. These results, though not quite decisive, favour the opinion that soluble matters pass unaltered into the roots of plants; and the idea is confirmed by the circumstance that the radical fibres of plants made to grow in infusions of madder are tinged red; and it may be considered as almost proved by the fact, that substances which are even poisonous to vegetables are absorbed by them. Sir H. Davy introduced the roots of a primrose into a weak solution of oxide of iron in vinegar, and suffered it to remain in it till the leaves became yellow; the roots were then carefully washed in distilled water, bruised, and boiled in a small quantity of the same fluid: the decoction of them passed through a filtre was examined by the test of infusion of nut-galls; the decoction gained a strong tint of purple, which proves that solution of iron had been taken up by the vessels or pores in the roots. Vegetable and animal substances, as is shewn by universal experience, are consumed in vegetation; and they can only nourish the plant by affording solid matters capable of being dissolved by water, or gaseous substances capable of being absorbed by the fluids in the leaves of vegetables; but such parts of them as are rendered gaseous, and that pass into the atmosphere, must produce a comparatively small effect, for gases soon become diffused through the mass of the surrounding air. The great object in the application of manure should be to make it afford as much soluble matter as possible to the roots of the plants; and that in a slow and gradual manner, so that it may be entirely consumed in forming the sap or organized parts of the plant. Mucilaginous, gelatinous, saccharine, oily, and extractive fluids, and solution of carbonic acid in water, are substances that in their un-

changed states contain almost all the principles necessary for the life of plants; but there are few cases in which they can be applied as manures in their pure forms; and vegetable manures, in general, contain a great excess of fibrous and insoluble matter, which must undergo chemical changes before they can become the food of plants. *Uric acid,* as has been shown by Dr. Egan, may be obtained from human urine by pouring an acid into it; and it often falls down from urine in the form of brick-coloured crystals. It consists of carbon, hydrogen, oxygen and azote; but their proportions have not yet been determined. Uric acid is one of the animal substances least liable to undergo the process of putrefaction. Whenever manures consist principally of matter soluble in water, it is evident that their fermentation or putrefaction should be prevented as much as possible; and the only cases in which these processes can be useful, are when the manure consists principally of vegetable or animal fibre. The circumstances necessary for the putrefaction of animal substances are similar to those required for the fermentation of vegetable substances; a temperature above the freezing point, the presence of water, and the presence of oxygen, at least in the first stage of the process. To prevent manures from decomposing, they should be preserved dry, defended from the contact of air, and kept as cool as possible. All *green succulent plants* contain saccharine or mucilaginous matter, with woody fibre, and readily ferment. They cannot, therefore, if intended for manure, be used too soon after their death. When *green crops* are to be employed for enriching a soil, they should be ploughed in, if it be possible, when in flower, or at the time the flower is beginning to appear, for it is at this period that they contain the largest quantity of easily soluble matter, and that their leaves are most active in forming nutritive matter. Green crops, pond weeds, the parings of hedges or ditches, or any kind of fresh vegetable matter, requires no preparation to fit them for manure. The decomposition slowly proceeds beneath the soil; the soluble matters are gradually dissolved, and the slight fermentation that goes on checked by the want of a free communication of air, tends to render the woody fibre soluble without occasioning the rapid dissipation of elastic matter. When old pastures are broken up and made arable, not only has the soil been enriched by the death and slow decay of the plants which have left soluble matters in the soil; but the leaves and roots of the grasses living at the time and occupying so large a part of the surface, afford saccharine, mucilaginous, and extractive matters, which become immediately the food of the crop, and the gradual decomposition affords a supply for successive years. *Rape cake*, which is used with great success as a manure, contains a large quantity of mucilage, some albuminous matter, and a small quantity of oil. This manure should be used recent, and kept as dry as possible before it is applied. It forms an excellent dressing for turnip crops; and is most economically applied, being thrown into the soil at the same time with the seed. Whoever wishes to see this practice in its highest degree of perfection, should observe the process on Mr. Coke's farm in Norfolk. *Malt dust* consists chiefly of the infant radicle separated from the grain. We have not a correct analysis of this manure; but there is great reason to suppose it must contain saccharine matter; and this will account for its powerful effects. Like rape cake it should be used as dry as possible, and its fermentation prevented. *Linseed cake* is too valuable as a food for cattle to be much employed as a manure. *The water* in which *flax* and *hemp* are steeped for the purpose of obtaining the pure vegetable fibre, has considerable fertilizing powers. It appears to contain a substance analogous to albumen, and likewise much vegetable extractive matter. It putrefies very readily. A certain degree of fermentation is absolutely necessary to obtain the flax and hemp in a proper state; the water to which they have been exposed should therefore be used as a manure as soon as the vegetable fibre is removed from it. *Sea weeds*, consisting of different species of fuci, algæ, and confervæ, are much used as a manure on the

sea coasts of Britain and Ireland. By digesting the common fucus, which is the sea weed usually most abundant on the coast, in boiling water, it yielded about one-eighth of a gelatinous substance, which had characters similar to mucilage. A quantity distilled gave nearly four-fifths of its weight of water, but no ammonia; the water had an empyreumatic and slightly sour taste; the ashes contained sea salt, carbonate of soda, and carbonaceous matter. The gaseous matter afforded was small in quantity, principally carbonic acid and gaseous oxide of carbon, with a little hydro-carbonate. This manure is transient in its effects, and does not last for more than a single crop, which is easily accounted for from the large quantity of water, or the elements of water, it contains. It decays without producing heat when exposed to the atmosphere, and seems as it were to melt down and dissolve away. *Dry straw* of wheat, oats, barley, beans and peas, and spoiled hay, or any other similar kind of dry vegetable matter is, in all cases, useful manure. In general, such substances are made to ferment before they are employed, though it may be doubted whether the practice should be indiscriminately adopted. There can be no doubt that the straw of different crops immediately ploughed into the ground affords nourishment to plants but there is an objection to this method of using straw from the difficulty of burying long straw, and from its rendering the husbandry foul. When straw is made to ferment, it becomes a more manageable manure; but there is likewise on the whole a great loss of nutritive matter. More manure is perhaps supplied for a single crop; but the land is less improved than it would be, supposing the whole of the vegetable matter could be finely divided and mixed with the soil. *Mere woody fibre* seems to be the only vegetable matter that requires fermentation to render it nutritive to plants. *Inert peaty matter* remains for years exposed to water and air without undergoing change; and in this state yields little or no nourishment to plants. Woody fibre will not ferment unless some substances are mixed with it, which act the same part as the mucilage, sugar, and extractive or albuminous matters, with which it is usually associated in herbs and succulent vegetables. Lord Meadowbank has judiciously recommended a mixture of common farmyard dung, for the purpose of bringing peats into fermentation; any putrescible or fermentable substance will answer the end; and the more a substance heats, and the more readily it ferments, the better will it be fitted* for the purpose. Woody fibre may be likewise prepared so as to become a manure by the action of lime. *Wood ashes* imperfectly formed, that is, wood-ashes containing much charcoal, are said to have been used with success as a manure. A part of their effects may be owing to the slow and gradual consumption of the charcoal, which seems capable, under other circumstances than those of actual combustion, of absorbing oxygen so as to become carbonic acid. Manures from animal substances, in general, require no *chemical* preparation to fit them for the soil. The great object of the farmer is to blend them with the earthy constituents in a proper state of division, and to prevent their too rapid decomposition. *Fish* forms a powerful manure in whatever state it is applied; but it cannot be ploughed in too fresh, though the quantity should be limited. It is easy to explain the operation of fish as a manure. The skin is principally gelatine; which, from its slight state of cohesion, is readily soluble in water: fat or oil is always found in fishes, either under the skin or in some of the viscera; and their fibrous matter contains all the essential elements of vegetable substances. *Bones* are much used as a manure in the neighbourhood of London. After being broken and boiled for grease, they are sold to the farmer. The more divided they are, the more powerful are their effects. The expence of grinding them in a mill would probably be repaid by the increase of their fertilizing powers; and in the state of powder they might be used in the drill husbandry, and delivered with the seed in the same manner as rape cake. Bone dust, and bone shavings, the refuse of the turning manufacture, may be advantageously employed in the same

way. *Horn* is a still more powerful manure than bone, as it contains a larger quantity of decomposable animal matter. *Hair, woollen rags* and *feathers* are all analogous in composition, and principally consist of a substance similar to albumen, united to gelatine. This is shown by the ingenious researches of Mr. Hatchett. The theory of their operation is similar to that of bone and horn shavings. The *refuse* of the different manufactures of *skin* and *leather* form very useful manures; such as the shavings of the currier, furriers' clippings, and the offals of the tan-yard and of the glue-maker. The gelatine contained in every kind of skin is in a state fitted for its gradual solution or decomposition; and when buried in the soil, it lasts for a considerable time, and constantly affords a supply of nutritive matter to the plants in its neighbourhood. *Blood* contains certain quantities of all the principles found in other animal substances, and is consequently a very good manure. During the putrefaction of urine the greatest part of the soluble animal matter that it contains is destroyed; it should consequently be used as fresh as possible: but if not mixed with solid matter, it should be diluted with water, as when pure it contains too large a quantity of animal matter to form a proper fluid nourishment for absorption by the roots of plants. Putrid urine abounds in ammoniacal salts; and though less active than fresh urine, is a very powerful manure. Amongst excrementitious solid substances used as manures, one of the most powerful is the *dung* of *birds* that feed on *animal food*, particularly the dung of sea birds. *Night soil*, it is well known, is a very powerful manure, and very liable to decompose. It differs in its composition; but always abounds in substances composed of carbon, hydrogen, azote, and oxygen. From the analysis of Berzelius, it appears that a part of it is always soluble in water; and in whatever state it is used, whether recent or fermented, it supplies abundance of food to plants. The disagreeable smell of night soil may be destroyed by mixing it with quicklime; and if exposed to the atmosphere in thin layers, strewed over with quicklime in fine weather, it speedily dries, is easily pulverized, and in this state may be used in the same manner as rape cake, and delivered into the furrow with the seed. The Chinese, who have more practical knowledge of the use and application of manures than any other people existing, mix their night soil with one-third of its weight of a fat marle, make it into cakes, and dry it by exposure to the sun. These cakes, we are informed by the French missionaries, have no disagreeable smell, and form a common article of commerce of the empire. The earth, by its absorbent powers, probably prevents, to a certain extent, the action of moisture upon the dung, and likewise defends it from the effects of air. After night soil, *pigeons' dung* comes next in order, as to fertilizing power. The dung of *domestic fowls* approaches very nearly in its nature to pigeons' dung. Uric acid has been found in it. It gives carbonate of ammonia by distillation, and immediately yields soluble matter to water. It is very liable to ferment. If the pure dung of cattle is to be used as manure, like the other species of dung which have been mentioned, there seems no reason why it should be made to ferment, except in the soil; or if suffered to ferment, it should be only in a very slight degree. The grass in the neighbourhood of recently voided dung, is always coarse and dark green; some persons have attributed this to a noxious quality in unfermented dung; but it seems to be rather the result of an excess of food furnished to the plants. A slight incipient fermentation is undoubtedly of use in the dunghill; for by means of it, a disposition is brought on in the woody fibre to decay and dissolve, when it is carried to the land, or ploughed into the soil; and woody fibre is always in great excess in the refuse of the farm. Too great a degree of fermentation is, however, very prejudicial to the composite manure in the dunghill; it is better that there should be no fermentation at all before the manure is used, than it should be carried too far. Independent of the general theoretical views unfavourable to this practice founded upon the nature and composition of

vegetable substances, there are many arguments and facts which show that it is prejudicial to the interests of the farmer. During the violent fermentation which is necessary for reducing farm-yard manure to the state in which it is called *short muck*, not only a large quantity of fluid, but likewise of gaseous matter is lost; so much so, that the dung is reduced one half, or two-thirds in weight; and the principal elastic matter disengaged, is carbonic acid with some ammonia; and both these, if retained by the moisture in the soil, as has been stated before, are capable of becoming an useful nourishment to plants. A great objection against slightly fermented dung is, that weeds spring up more luxuriantly where it is applied. If there are seeds carried out in the dung they certainly will germinate; but it is seldom that this can be the case to any extent; and if the land is not cleansed of weeds, any kind of manure fermented or unfermented will occasion their rapid growth. If slightly fermented farm-yard dung is used as a top dressing for pastures, the long straws and unfermented vegetable matter remaining on the surface should be removed as soon as the grass begins to rise vigorously by raking, and carried back to the dunghill: in this case no manure will be lost, and the husbandry will be at once clean and economical. In cases when farm-yard dung cannot be immediately applied to crops, the destructive fermentation of it should be prevented as much as possible: the principles on which this may be effected have been already alluded to. The surface should be defended as much as possible from the oxygen of the atmosphere; a compact marle, or a tenacious clay, offers the best protection against the air; and before the dung is covered over, or as it were, sealed up, it should be dried as much as possible. If the dung is found at any time to heat strongly, it should be turned over, and cooled by exposure to the air. When dung is to be preserved for any time, the situation in which it is kept is of importance. It should, if possible, be defended from the sun. To preserve it under sheds would be of great use; or to make the site of a dunghill on the north side of a wall. The floor on which the dung is heaped, should, if possible, be paved with flat stones; and there should be a little inclination from each side towards the centre, in which there should be drains connected with a small well furnished with a pump, by which any fluid matter may be collected for the use of the land. It too often happens that a dense mucilaginous and extractive fluid is suffered to drain away from the dunghill, so as to be entirely lost to the farm. *Street* and *road dung*, and the *sweepings of houses* may be all regarded as composite manures; the constitution of them is necessarily various, as they are derived from a number of different substances. These manures are usually applied in a proper manner, without being fermented. *Soot*, which is principally formed from the combustion of pitcoal or coal, generally contains likewise substances derived from animal matters. This is a very powerful manure. It affords ammoniacal salts by distillation, and yields a brown extract to hot water, of a bitter taste It likewise contains an empyreumatic oil. Its great basis is *charcoal*, in a state in which it is capable of being rendered soluble by the action of oxygen and water. This manure is well fitted to be used in the dry state, thrown into the ground with the seed, and requires no preparation. The doctrine of the proper application of manures from organized substances, offers an illustration of an important part of the economy of nature, and of the happy order in which it is arranged. The death and decay of animal substances tend to resolve organized forms into chemical constituents; and the pernicious effluvia disengaged in the process, seems to point out the propriety of burying them in the soil, where they are fitted to become the food of vegetables. The fermentation and putrefaction of organized substances in the free atmosphere are noxious processes; beneath the surface of the ground they are salutary operations. In this case the food of plants is prepared where it can be used; and that which would offend the senses and injure the health, if exposed, is converted by gradual processes into forms of beauty and of

usefulness; the fœtid gas is rendered a constituent of the aroma of the flower, and what might be poison, becomes nourishment to animals and to man.

MARBLE is distinguished from limestone by superior weight and by superior hardness and compactness, so that it assumes a brighter polish. But many of the alabasters will scratch marble, being, of course, of a still harder nature. While the Egyptians often employed the eternal granite, the Greek and Roman Architects who required greater roundness and softness of forms, chiefly used marble as more easily wrought, and likewise more abundant in their countries; nor does its duration seem much inferior to that of granite and porphyry when sufficiently pure and unmixed with argil, for not to mention the beautiful statues (which are often under shelter) ancient temples have suffered more from the hand of bigotry or barbarism, than from the lapse of time. The subject of marble is almost infinite, as no mineral substance affords such innumerable diversities, or has so much attracted the attention of mankind. The chief Egyptian monuments are in granite and basalt, but in the museum at Paris, and other princely collections, there are many Egyptian statues and other monuments in the rosso antico, the ancient red, the peculiar marble of Upper Egypt or of Ethiopia, for the cataracts were anciently reputed to divide these countries, and Syene was esteemed the last town of Egypt on the very confines of Ethiopia. In passing to the Grecian, first occurs the white marble of Paros, sometimes called Lychnites by the ancients, because the quarries were explored by lamplight. The Parian marble was employed by the most ancient Greek sculptors about the fortieth Olympiad, but being of a yellowish tint, and coarse grain, it was afterwards supplanted by the marble of Siena Etruria, as afterwards by that of Carrara in the same vicinity. The Venus de Medici, Diana hunting, Venus leaving the baths, the colossal Minerva, the Juno of the capitol, and several others, are of Parian marble. The celebrated Parian tables at Oxford, which have illustrated many points of ancient chronology, are also inscribed upon the same stone. Pentelican marble from the vicinity of Athens, is white like the former, but with a finer and more compact grain. It sometimes presents blackish veins from a siderous mixture, and sometimes green veins of the talcous kind, so that it is at Rome called statuary Cipoline. The vague name of Greek marble has been given to a fine grained and hard kind of a snowy whiteness. It was from several islands in the Archipelago, as Scio, Samos, &c. At Venice and in different towns of Lombardy are columns and altars of a singular marble, so transluscent that the light of a candle is visible through pretty thick masses; this is, perhaps, the Cappadocian plengites. Tables of ancient elastic marble occur in the palace Borghese at Rome. White marble is found at Luni (the ancient Luna) and Carrara, on the shores of Tuscany. Though these two places be nearly adjacent, yet some assert that the marble of Luni is finer than that of Carrara, and free from the grey veins that sometimes appear in the latter. The Antinous of the capitol is said to be of Luni; that of Carrara, as just mentioned, often presents grey veins, so that it is difficult to procure blocks of an uniform white. It has been much used for chimney-pieces in England, and is often mingled with the yellow and dull purplish bricia of Sienna, but the quarries are said to have been opened at least as early as the time of Julius Cæsar. The Carrara marble has sometimes greenish talcous veins like the Cipolina, and sometimes crystals of iron. But the most beautiful specimens are those which contain, in little cavities, rock crystals of the purest water, called, in Italy, diamonds of Carrara. White marble of mount Hymettus in Attica, rather inclining to grey, was the first foreign marble introduced to Rome, where this moderate magnificence was thought so extraordinary, that Crassus the orator was exposed to the sarcasms of Marcus Brutus, because he had adorned his house with six columns twelve feet high of Hymettian marble. Such were the chief white marbles employed by the ancients. The ancient black is so intense, that when placed beside those of Dinan and Namur, it makes them

Contortion of Marble and Schist in Iona.

Agate Pebble.

appear grey. Other ancient marbles may be classed among the calcareous glutenites. To ennumerate modern marbles would be infinite, but the more remarkable of our own country may be noticed. England.—Some of the most beautiful will be found among the conchetic or shell kind. The black marble of Derbyshire:—intense black marble with distant white spots. Somersetshire:—the Cottam marble found near Bristol, has black dendritic delineations. Brown marble variously veined, from Devonshire:—this is the marble from Plymouth and Torbay, mentioned by Da Costa, as of a fine deep black, beautifully variegated with irregular veins of red, and yellow, and white, much was brought to London and worked into chimney-pieces, tables, &c. He also describes a marble of a dull yellow with many dots, streaks, and spots of black, as found at Yeovil in Somersetshire, and elegant tables of it may be seen in that county; though it is not capable of a fine polish. The gre n and red marbles of Anglesea are much celebrated. Scotland.—White statuary marble of Assynt:—white marble with long veins of a different tint from Durnesse, red and white marble of Boyne. The beautiful rose-coloured marble of Tircy, mingled with si lerite, &c. The same isle presents a beautiful white marble with veins of Nephrite. Numerous other marbles might be explored in the Highlands of Scotland, and a French author is singularly unjust, when he says that the British isles are poor in marbles. Ireland.—Near the celebrated lake of Killarney, are found white and red, and black and white marbles. Indolence and ignorance have prevented further research. The fine black marble of Kilkenny is conchete, but the north of Ireland yields a brown marble, and one of a pale white, like earthenware.

MARLE, consists of calcareous earth mixed with alumina. The quantity of calcareous earth may be ascertained by dissolving it with muriatic acid, washing the solution, and ascertaining the difference of weight.

MARCASITE. See *Pyrites*.

MARGARIC ACID is obtained from fat.

MARMOR METALLICUM. Native sulphate of barytes.

MARS. The mystical name given by the alchymists to iron.

MASSICOT. Yellow oxide of lead. See *Lead*.

MASTIC. A resinous substance in the form of tears, of a very pale yellow colour, and farinaceous appearance, having little smell, and a bitter astringent taste. It flows naturally from the tree, but its produce is accelerated by incisions. The lesser turpentine tree and the lentiscus afford the mastic of commerce. No volatile oil is obtained from this substance when distilled with water. Pure alcohol and oil of turpentine dissolve it; water scarcely acts upon it; though by mastication it becomes soft and tough, like wax. When chewed a little while, however, it is white, opaque and brittle, so as not to be softened again by chewing. The part insoluble in alcohol much resembles in its properties caoutchouc. It is used in fumigations, in the composition of varnishes, and is supposed to strengthen the gums.

MATRIX. The earthy or stony matter which accompanies ores, or envelopes them in the earth.

MEADOW-ORE. Conchoidal bog-iron ore.

MEASURES. The English measures of capacity, are according to the following table:—

One gallon, wine measure, is equal to	four quarts.
One quart - -	two pints.
One pint, - -	28·875 cubic inches.

The pint is subdivided by chemists and apothecaries into 16 ounces. The gallon, quart, and pint, ale measure, are to the measures of the same denominations, wine measure, respectively, as 282 to 231.

MEERSCHAUM, a mineral consisting of silica 4·15, magnesia 18·25, lime 0·50, water and carbonic acid 39. When first dug it is soft and greasy, and lathers like soap. Hence, it is used by the Tartars for washing clothes. The Turks manufacture it into tobacco pipes.

MEIONITE, a felspar found in crystals, of a prismato-pyramidal shape, found at Monte Somma, adjacent to Vesuvius near Naples.

MELANITE, a mineral consisting of 35·5 silica balumina, 32·5 lime, 25·25 oxide of iron, with a minute portion of manganese.

MELASIC ACID, found in Melasses, supposed to be the same as the acetic acid.

MELLATES, compounds of the mellitic acid and salifiable bases.

MELLITE, or **HONEYSTONE**, consists of alumine 16, mellitic acid 46, and water of crystallization 38.

MELLITIC ACID, was obtained by Klaproth, by reducing the mellite, or honeystone, to powder, and boiling it with seventy times its weight of water: the acid may be dissolved and separated from the alumina by filtration.

MELTING (the act of), changing from a solid to a liquid state.

MENASCHANITE, a mineral containing 51 oxide of iron, 45·25 oxide of titanium, 0·25 oxide of manganese, 3·5 silica.

MENILITE, a sort of indivisible quartz.

MENISPERMIC ACID, supposed to be found in the menispermum cocculus.

MEPHITIC AIR. Carbonic acid gas.

MENSTRUUM, a solvent.

MERCURY, is a metal which in our climate is always fluid, but in intense cold it becomes solid, and then resembles silver in appearance, and is malleable. It is sometimes found native, but much more frequently combined with sulphur, when it is denominated cinnabar. It is separated from the sulphur by distillation with quicklime or iron filings. Mercury is obtained abundantly in the Austrian territories, and in South America. Mercury has a great affinity to other metals. Dip a shilling in mercury, it will be encrusted over, and will require to be rubbed very much before the mercury is got off. The same circumstance will occur if any other metal be put in mercury. Rub some quicksilver and tinfoil together, and they will unite into one mass. Such a composition is called an amalgam. Mercury and lead will also combine. If lead, bismuth, and mercury, are united together, the amalgam will be equally fluid with the simple mercury itself. From this circumstance, dishonourable dealers frequently impose on the public this impure composition, and when the metal is to be used medically, dangerous consequences are the result. Mercury is used in barometers, thermometers, in silvering looking-glasses, and forming amalgams for gilding and silvering metals; also, in the making of vermillion. In countries where there are gold and silver mines, it is employed in separating the precious metals from extraneous matter. Mercury is nearly fourteen times the weight of water, and is the heaviest of all metals after gold and platinum. In consequence of its great weight, if a piece of stone, iron, lead, or silver, be put in a cup of mercury, it will float at the surface in the same manner, and for exactly the same reason, as a piece of wood in water. Mercury is readily soluble in acids, as may easily be ascertained, and from its very extensive use in medicine, there are innumerable preparations of it, by which it may be exhibited in powders, pills, or drops, to the patient. The most usual is calomel, which is a preparation of mercury and the muriatic acid. One preparation of mercury, named corrosive sublimate, is a most deadly poison. If into a solution of corrosive sublimate, a few drops of a solution of potass, or a little limewater, be let fall, the liquor, formerly clear, will at once become of an orange colour, and a precipitation will soon take place. If a few drops of acid be then let fall, it will become quite clear. Mercury will readily unite with sulphur. Melt some sulphur in a crucible on the fire, and then add a little mercury, and stir the whole together, and a sulphuret of mercury or cinnabar will be formed. Vermilion is a beautiful scarlet pigment, prepared from mercury and sulphur, and is called by chemists the red sulphuretted oxide of mercury. The Dutch are the chief manufacturers of it in Europe; but it is said, that the vermillion produced in China is still more brilliant in its appearance. The property of mercury dissolving a certain portion of gold and silver, enabled alchymists to impose upon mankind, and make it appear as if they had succeeded in a small degree in discovering the secret of turning me-

tals into gold and silver. In their operations they employed mercury, in which small portions of these metals had been dissolved; and as the mercury was evaporated by great heat, and left the gold and silver behind, the bystanders were made to believe that these metals had actually been produced in the operation by the skill of the experimentalist. They would easily have been detected, if a small portion of the mercury they used had been exposed to great heat, and made to rise in fumes, as the nobler metals would have been left behind. Calomel is now called in the nomenclature of the day, the protochloride of mercury, and corrosive sublimate is called the deuto-chloride. Mercury fries at 39 below Zero, and boils at 656° Farenheit. The sulphuric acid does not act on this metal, unless it be well concentrated and boiling. For this purpose mercury is poured into a glass retort, with nearly twice its weight of sulphuric acid. As soon as the mixture is heated, a strong effervescence takes place, sulphureous acid gas escapes, the surface of the mercury becomes white, and a white powder is produced: when the gas ceases to come over, the mercury is found to be converted into a white, opaque, caustic, saline mass, at the bottom of the retort, which weighs one-third more than the mercury, and is decomposed by heat. Its fixity is considerably greater than that of mercury itself. If the heat be raised, it gives out a considerable quantity of oxygen, the mercury being at the same time revived. Water resolves it into two salts, the bisulphate and subsulphate: the latter is of a yellow colour. Much washing is required to produce this colour, if cold water be used; but if a large quantity of hot water be poured on, it immediately assumes a bright lemon colour. In this state it is called turbith mineral. The other affords by evaporation, small, needly, deliquescent crystals. The fixed alkalis, magnesia, and lime, precipitate oxide of mercury from its solutions; these precipitates are reducible in closed vessels by mere heat without addition. The nitric acid rapidly attacks and dissolves mercury, at the same time that a large quantity of nitrous gas is disengaged: and the colour of the acid becomes green during its escape. Strong nitric acid takes up its own weight of mercury in the cold; and this solution will bear to be diluted with water. But if the solution be made with the assistance of heat, a much larger quantity is dissolved; and a precipitate will be afforded by the addition of distilled water, which is of a yellow colour if the water be hot, or white if it be cold, and greatly resembles the turbith mineral produced with sulphuric acid: it has accordingly been called nitrous turbith. All the combinations of mercury and nitric acid are very caustic, and form a deep purple or black spot upon the skin. They afford crystals, which differ according to the state of the solution. When nitric acid has taken up as much mercury as it can dissolve by heat, it usually assumes the form of a white saline mass. When the combination of nitric acid and mercury is exposed to a gradual and long continued low heat, it gives out a portion of nitric acid, and becomes converted into a bright red oxide, still retaining a small portion of acid. This is known by the name of red precipitate, and is much used as an escharotic. When red precipitate is strongly heated, a large quantity of oxygen is disengaged, together with some nitrogen, and the mercury is sublimed in the metallic form. Nitrate of mercury is more soluble in hot than cold water, and affords crystals by cooling. It is decomposed by the affusion of a large quantity of water, unless the acid be in excess. A fulminating preparation of mercury was discovered by Mr. Howard. A hundred grains of mercury are to be dissolved by heat in an ounce and a half, by measure, of nitric acid. This solution being poured cold into two ounces, by measure, of alcohol, in a glass vessel, heat is to be applied, till effervescence is excited. A white vapour undulates on the surface, and a powder is gradually precipitated, which is immediately to be collected on a filter, well washed, and cautiously dried with a very moderate heat. This powder detonates loudly by gentle heat, or slight friction. The acetic and most other acids combine with the oxide of mercury, and precipitate it from its solution in the nitric acid. When one part of native sulphuret

of antimony is triturated, or accurately mixed with two parts of corrosive sublimate, and exposed to distillation, the chloride combines with the antimony, and rises in the form of the compound called butter of antimony; while the sulphur combines with the mercury, and forms cinnabar. If antimony be used instead of the sulphuret, the residue which rises last consists of running mercury, instead of cinnabar. Mercury, being habitually fluid, very readily combines with most of the metals, to which it communicates more or less of its fusibility. When these metallic mixtures contain a sufficient quantity of mercury to render them soft at a mean temperature, they are called amalgams. It very readily combines with gold, silver, lead, tin, bismuth, and zinc; more difficultly with copper, arsenic, and antimony; and scarcely at all with platina or iron. It does not unite with nickel, manganese, or cobalt; and its action on tungsten and molybdena is not known. Looking-glasses are covered on the back surface with an amalgam of tin. Some of the uses of mercury have already been mentioned in the present article. The amalgamation of the noble metals, water-gilding, the making of vermilion, the silvering of looking-glasses, the making of barometers and thermometers, and the preparation of several powerful medicines, are the principal uses to which this metal is applied. Scarcely any substance is so liable to adulteration as mercury, owing to the property which it possesses of dissolving completely some of the baser metals. This union is so strong, that they even rise along with the quicksilver when distilled. The impurity of mercury is generally indicated by its dull aspect; by its tarnishing, and becoming covered with a coat of oxide, on long exposure to the air; by its adhesion to the surface of glass; and, when shaken with water in a bottle, by the speedy formation of a black powder. Lead and tin are frequent impurities, and the mercury becomes capable of taking up more of these if zinc or bismuth be previously added. In order to discover lead, the mercury may be agitated with a little water, in order to oxidize that metal. Pour off the water, and digest the mercury with a little acetic acid. This will dissolve the oxide of lead, which will be indicated by a blackish precipitate with sulphuretted water. Or to this acetic solution add a little sulphate of soda, which will precipitate a sulphate of lead, containing, when dry, 72 per cent of metal. If only a very minute quantity of lead be present in a large quantity of mercury, it may be detected by solution in nitric acid, and the addition of sulphuretted water. A dark brown precipitate will ensue, and will subside if allowed to stand a few days. One part of lead may thus be separated from 15263 parts of mercury. Bismuth is detected by pouring a nitric solution, prepared without heat, into distilled water; a white precipitate will appear if this metal be present. Tin is manifested, in like manner, by a weak solution of nitro-muriate of gold, which throws down a purple sediment; and zinc, by exposing the metal to heat. The black oxide is rarely adulterated, as it would be difficult to find a substance well suited to this purpose. If well prepared, it may be totally volatilized by heat. The red oxide of mercury by nitric acid is very liable to adulteration with red lead. It should be totally volatilized by heat. Red sulphuret of mercury is frequently adulterated with red lead, which may be detected by heat. Corrosive muriate of mercury. If there be any reason to suspect arsenic in this salt, the fraud may be discovered as follows:—Dissolve a small quantity of the sublimate in distilled water; add a solution of carbonate of ammonia till the precipitation ceases, and filter the solution. If, on the addition of a few drops of ammoniated copper to this solution, a precipitate of a yellowish green colour be produced, the sublimate contains arsenic. Sub-muriate of mercury, or calomel, should be completely saturated with mercury. This may be ascertained by boiling, for a few minutes, one part of calomel with a thirty-second part of muriate of ammonia in ten parts of distilled water. When carbonate of potash is added to the filtered solution, no precipitation will ensue, if the calomel be pure. This preparation, when rubbed in an earthen mortar with pure ammonia, should

become intensely black, and should exhibit nothing of an orange hue.

MESOTYPE, a kind of zeolite.

METALS. The metals are a most important class of bodies, as it is on the employment of them that almost all the arts of life depend. They furnish the tools by which works are carried on, and the material the most firm, solid, and beautiful. Without them, even in the most favoured clime, men could scarcely rise beyond the state of savages. It is by their use that the work of a year can be performed in one day. In medicine the metals are highly important, as they furnish the most powerful means of effecting a salutary change on the human frame, and it is chemistry which has taught the most safe and efficient modes of employing them. Metals are, in general, of greater specific gravity than other bodies; they are opaque, but exhibit a mirror-like lustre, which is one of their best distinguishing marks. They are insoluble in water, and present a convex surface when melted in earthen vessels. Sometimes they are found native, that is, pure, and uncombined with other substances, so as to have the appearance and properties of metals. In most cases, however, metals are found united with other substances, in the form called ores, and are to be separated by violent heat, and other means. Metals and metaliferous ores are found in various places:—under water, in beds of rivers, lakes, and seas, and chiefly at the flexures of these. Such are the auriferous and ferruginous sands, grains of native gold, ochres, and fragments of ores, washed from mines—dissolved in water; such are the vitriolic waters, containing iron, copper, or zinc:—upon the surface of the earth; such are many ochres, metaliferous stones, sands, clays, and lumps of ores. Mr. Gmelin says, that in the northern parts of Asia, ores are almost always found upon or near the surface of the ground. Under the surface of the earth: when the quantity of these collected in one place is considerable, it is called a mine. Subterraneous metals and ores are differently disposed in different places. Some are infixed in stones and earths, forming nodules, or spots diversely coloured. Some are equably and uniformly diffused through the substance of earths and stones, to which they give colour, density, and other properties. Such are the greatest part of those earths, stones, sands, clays, crystals, flints, gems, and floors, which are coloured. Some form strata in mountains. Such are the slates containing pyrites, copper ore, lead ore, silver ore, or blend. These lie in the same direction as the strata of the stones betwixt which they are placed, but they differ from the ordinary strata in this circumstance, that the thickness of different parts of the same metaliferous stratum is often very various, whereas the thickness of the stony strata is known to be generally very uniform. Fragments of ores are frequently found accumulated in large subterraneous cavities, in fissures of mountains, or interposed betwixt the strata of the earth. These are loose, unconnected, frequently involved in clay, and not accreted to the contiguous rocks or strata, immediately, nor by intervention of spar or quartz, as the ores found in veins are. Tin and iron mines are frequently of the kind here described. Large entire masses of ore are sometimes found in the stony strata of mountains. These are improperly called cumulated veins, because their length, relatively to their breadth and depth, is not considerable. Some instances are mentioned of entire mountains consisting of ore. Such is the mountain Taberg in Smoland, and such are the mountains of Kerunavara and Luosavara, in Lapland,—the former of which is 1400 perches long, and 100 perches broad. These mountains consist of iron ore. Lastly and chiefly, metals and ores are found in oblong tracts, forming masses called veins, which lie in the stony strata composing mountains. Metals are procured from ores, by washing, wasting, and fusion. By washing the ore after it is reduced to powder, it is separated from salts and other matter soluble in water. By wasting the ores, or subjecting them some time to considerable heat, arsenic, sulphur, and other matters, are dissipated, which if found with the metals, would greatly injure their quality. A very small portion of sulphur, united with wrought iron, would render it very brittle, and almost use-

less. Malleability is that property by which a metal may be hammered out into a broad leaf, without its parts separating asunder. No metal is possessed of such a degree of malleability as gold. Hence we see, that notwithstanding the great value of this metal, gold leaf may be made so thin, and afforded at a low price, and in the art of gilding is spread over a large surface. Silver is also capable of a great degree of malleability. The following list shews what metals in common use are malleable, and the order in which they possess that property.

Gold	Platinum
Silver	Lead
Copper	Zinc
Tin	Iron.

Ductility is the property of metals, by which they may be drawn out into wire,—of which they are possessed in the following order.

Gold	Copper
Silver	Zinc
Platinum	Tin
Iron	Lead.

Wire-drawing is the art of drawing out long bars of metal, by pulling it through holes in a plate of steel, or other fit metallic compound. In order that a wire may be drawn, it is requisite that the metal should have considerable tenacity. Gold, silver, iron, steel, copper, and their compounds, are most commonly used in the arts. The process is of considerable simplicity.—A number of holes progressively smaller and smaller, are made in a plate of steel, and the pointed end of a bar of metal being passed through one of them, is forcibly drawn by strong pincers, so as to elongate it by the pressure arising from the re-action of the greatest hole. This is the wire; and it is again passed in like manner through another hole, a little smaller, and by continuing the process, the wire has its length increased and its diameter diminished to a very great degree. The largest wire may be nearly an inch in diameter, and the smallest ever made was about the one-thousandth part of an inch; but it is said that silver wire has been made one-fifteen-hundredth of an inch in diameter. The size of these small wires may be ascertained from the weight of a known measure of length, and the specific gravity of the metal, or, less correctly, the wire may be wound round a pin, and the number of turns counted which make a given length. Wires are drawn square, and of other figures in their sector. In particular, they are drawn grooved, so that any small part will form the pinion of a watch or clock-work. As the violent action of the drawing-plate renders the wire hard and brittle, it is necessary to anneal it several times during the course of drawing. Very small holes are made by hammering up the larger, and the point, in very thin wire, by rolling or crushing the end by a smooth burnishing tool, upon a polished plate. Gold and silver wire is made of cylindrical ingots of silver, covered over with a skin of gold, and thus drawn successively through a vast number of holes, each smaller and smaller, till at last it is brought to a fineness exceeding that of an hair. That admirable ductility which makes one of the distinguishing characters of gold, is no where more conspicuous than in this gilt wire. A cylinder of 48 ounces of silver, covered with a coat of gold only weighing one ounce, as Dr. Halley informs us, is usually drawn into a wire, two yards of which weigh no more than one grain; whence, 98 yards of the wire weigh no more than 49 grains; and one single grain of gold covers the 98 yards; so that the thousandth part of a grain is above one-eighth of an inch long. He also, on computing the thickness of the skin of gold, found it to be $\frac{1}{134,500}$ part of an inch. Yet so perfectly does it cover the silver, that even a microscope does not discover any appearance of the silver underneath. Mr. Rohault likewise observes, that a like cylinder of silver covered with gold, two feet eight inches long, and two inches nine lines in circumference, is drawn into a wire 307,200 feet long, - 115,200 times its former length. M. Boyle relates, that eight grains of gold covering a cylinder of silver, are commonly drawn into a wire 13,000 feet long. Silver wire is the same with gold wire, except that the latter is gilt, or covered with gold, and the other is not. There are also counterfeit gold and silver wires,—the first made of a cylinder of copper silvered over, and then covered with gold, and the se-

cond of a like cylinder of copper, silvered over, and drawn through the iron, after the same manner as gold and silver wire. Brass wire is drawn after the same manner as the former. Of this there are divers sizes, suited to the different kinds of work. The finest is used for the strings of musical instruments, as spinnets, harpsichords, menusichords, &c. The pin-makers likewise use vast quantities of wire to make their pins of. Iron wire is drawn of various sizes, from half an inch to one-tenth of an inch diameter. The first iron that runs from the stone, when melting, being the softest and toughest, is preserved to make wire of. It will be seen that gold and silver, in addition to their greater lustre and beauty, are possessed in the greatest degree of the most valuable properties—malleability and ductility. Gold has also this great advantage, that it is not liable to rust, and cannot ever be dissolved by the use of any one acid. If the nations of the world had therefore not employed it as a circulating medium in commerce, it would have been still of much greater value than any other metal. Metals differ from each other in the degree with which their particles adhere, or, as it is called, in tenacity, according to the following order,

Iron	Gold
Copper	Zinc
Platinum	Tin
Silver	Lead.

It would be to no purpose to state, in pounds, and fractions of a pound, what weights wire of equal thickness would sustain, as the results will often be extremely various in different wires of the same metal. Metals are all susceptible of fusibility, or of being melted by heat, but at very different degrees of temperature. Mercury, which in the severest cold of winter in Russia, when the thermometer sinks to 40° below 0°, becomes solid, and is then malleable like lead, but in our climate it is always in a fluid state. Tin may be easily melted in an iron spoon or crucible, over the fire, at a heat about 450°. Lead requires a greater heat, or about 600°. Zinc requires a heat of about 700°, and antimony of 800°. Silver, gold, and copper require a greater heat, but may be melted in a crucible over a very strong fire, or when a stream of air is forced from a powerful bellows. A copper halfpenny may be put into the fire, and by blowing on it with a common bellows, we may see it melted, and the metal fall in drops. It is well known what prodigious heat is required to fuse iron in our furnaces. Vast streams of air, by the operation of powerful machinery, are forced upon the burning charcoal, which is thus raised to a most violent heat. When an opening is made in the lower part of the furnace, the melted metal rushes out in a stream, and is received in large pans of iron lined with clay; and it is poured into the moulds prepared for its reception. This is called cast iron. Platinum is most difficult of fusion. Hence, a spoon made of platinum is very convenient in the melting of metals, as it will endure any degree of heat which may be applied. Platinum, and various metals of rare occurrence, may be fused by means of an inflamed current of oxygen and hydrogen, or by means of the intense heat produced by wires from the opposite ends of a Voltaic Galvanic Battery. At a heat still greater than what is necessary to render them fusible, metals may be made to become volatile, or rise in vapour. A little mercury placed in an iron spoon, or in a crucible, and put on the fire, soon rises in fumes, and is dissipated. Arsenic and zinc are rendered volatile by a red heat. By means of the heat produced in the focus of a large burning-glass, gold and silver may be rendered volatile. The specific gravity of several of the metals is as follows, water being the standard, and stated at 1.

Platinum	21·0
Gold - -	19·3
Silver - -	10·5
Copper -	8·9
Iron - -	7·8
Tin - - -	7·3
Lead - -	11·4
Mercury -	13·5
Zinc - -	7·0
Bismuth -	9·8
Antimony -	6·7
Arsenic -	8·4
Cobalt - -	8·0
Manganese	6·8

It ought to be observed, that the above can only be considered as the *average*; for in different pieces of

the same metal, the specific gravity will be different, as melting or hammering a metal causes an alteration.

METEORILITE. See *Aerolite*.

METEOROLOGY is the application of natural philosophy to the constant or variable phenomena going on in the mass of the atmosphere, or at the surface of the earth, by the general action of natural agents, such as heat, electricity, and magnetism. In it are comprehended the uneqval distribution of heat upon the earth, the laws of its variations in the different seasons of the year, the decrease of density, and the failing of the temperature of the atmospheric strata at different heights, winds, clouds, fogs, rain, snow, hail, thunder, and water-spouts. For a long time also, in this science, were included all luminous appearances, such as rainbows, halos, at present explained by the science of optics; so also were the comets now known to be real heavenly bodies; likewise fire-balls which are now known to be real solid bodies, endowed with a very rapid motion of their own, which fall sometimes on the earth when they have exhausted their proper velocity in traversing the atmosphere. These phenomena have been withdrawn from meteorology, as they have become better known, but there are still left to this science, others which perhaps have not more connexion with it, on account of their cause being unknown; such are the aurora borealis, and the relations of this phenomenon with the direction of the magnetic needle. It is seen from this exposition, that many of the facts which belong to meteorology properly called, have been treated of separately in different parts of this work; it will be sufficient, then to recal them under the common point of view in which we see them at present, and to enter more into detail with the rest, of which we have not yet made special mention. Let us begin then with those which relate to the general state of the globe. The distribution of heat at the surface of the earth, and below this surface at the little depths to which we can penetrate, appears to depend solely on the mean annual height of the sun above the horizon, that is to say, on the latitude of the places. The temperature below ground is evidently constant at every place; it is highest of all under the equator when it rises to 27 deg. 6 of the centesimal thermometer, and decreases gradually in going towards the poles, where it falls to zero, or perhaps below it. The temperature of the atmosphere near the surface of the earth, experiences in every place much greater variations, which produce alternate changes of seasons. But these periodic oscillations disappear at a small depth, so that in every place the mean of all the annual temperature is generally equal to the temperature below ground; by which means we may deduce the one of these results from the other. It appears also, that in every place the mean of the highest and the lowest temperatures is still the same as the preceding. But with an equal latitude the absolute degree of the mean temperature varies with the height. The general laws of the equilibrium of gaseous masses being applied to the atmosphere, shew that the strata which compose it ought to diminish in proportion as they are at a greater height. The law of this decrease depends on the temperature of the strata, which cannot be determined but from observation. In the most usual state of the atmosphere, it is found that the temperature decreases equally with the height, in all climates, if the temperature at setting out be the same. But the law of this progression varies with the point at which we set out; so that in the temperate zones, for instance, according to the observation of Saussure, it is in winter 230 metres for each degree of the centesimal scale, and 160 metres in summer. There is, then, a height where this progressive cooling attains the term of ice; hence, the existence of eternal snow on the high mountains, and the unequal elevation of the point where it commences in different climates. The vertical decrease of the temperature varies also with the seasons, the exposure of places, or even with the more or less transparent state of the sky, so that the only way of knowing it with certainty, is to make direct observation. This operation is not possible, except for the small heights to which we can reach, but within these limits, when an attempt is made to determine it, we may, according to the laws of the

equilibrium of gases, calculate the decrease of density of the strata of the air, and deduct a formula, which enables us to calculate the difference of level from the heights of the barometer, and the temperatures observed at two extremities of a column of air. It is ascertained of the barometer, that it varies very little in every place between the tropics, and only following a regular diurnal period, whilst its oscillations become greater and greater, according to the distance from the equator. This fact shews that there are produced considerable variations in the pressure of the atmosphere, which the column of mercury measures; but no certain reason can be assigned for these variations. On the lakes of Geneva and Neufchatel, and in general on all large lakes, is observed a phenomenon which appears to be connected with the preceding; which is, that sometimes the waters all at once rise several feet in certain points of their banks, and remain a longer or shorter time in this extraordinary state of elevation. This phenomenon is known in Switzerland under the name of the seches. It may be presumed that it is the accidental result of a sudden inequality of the atmospheric pressure on different points of the lake; but if such be the cause, it ought to shew itself in its influence on the barometer, and to make it rise to unequal heights in the parts of the lake where the waters have an unequal level. M. Vaucher made a great number of observations which appear to confirm this consequence. In general, it is evident that in a mass so large and so moveable as the atmosphere, the slightest causes of agitation may produce the greatest and most durable perturbations. It is evident, then, that like effects ought to result from the small local variations which happen in the temperature, and that the greatest and most constant ought to result from the annual motion of the sun from one side to the other of the equator, according as the influence is more or less powerful, which he exercises upon the earth and upon the atmosphere at different seasons. Such are, probably, the most usual causes of these agitations, which often continue a long time, and which are produced in the atmosphere, and are called winds. The greatest velocity of wind which has been observed, is about 40 or 50 metres a second; when it blows with this fury, it overturns houses, tears up trees, raises the waves of the sea, excites tempests, and takes the name of hurricane. Within the tropics, are observed regular winds which blow from east to west, and which are called trade winds. They are a mechanical consequence of the constant presence of the sun above the equatorial regions. As he warms the strata of air in the torrid zone, he dilates them according as they are presented to his influence by the motion of the earth. He forms also a kind of equatorial equator of air, higher than the rest of the atmosphere, of which the superior strata being no longer laterally supported, must fall off to the north and south towards the poles. To compensate this, the cold strata of air situated near the surface of the polar regions, ought to blow towards the equator to replace those which are borne up; which to produce two opposite currents in the direction of the meridian, the one on high from the equator towards the pole, and the other below from the pole towards the equator. Now the particles of air which compose the last current, have but a very small velocity of rotation, which is that of the parallel of the earth which they have left. In their progress towards the equator they arrive successively over other parallels of which the velocity of rotation from west to east is much more rapid; they cannot, then, revolve so fast as the points of these parallels, and consequently when a vessel, a tree, a mountain, or any other obstacle situated in these latitudes in revolving with the earth from west to east, meets them, they must give a shock in an opposite direction, that is to say from east to west, with all that which they want of velocity. Such is the simple and natural explanation of the trade winds. It is evident that the annual passage of the sun from one side to the other of the equator, ought to prevent them from being rigorously directed in this plane at all times of the year; accordingly, it is observed, that the direction on which they blow, varies about four degrees

on each side of the equator. The cause which produces them ought, evidently, to act beyond the tropics, and even in our climates; but its effect must there be much weaker, on account of the diminished heat of the sun, and of the smaller difference of the velocities of rotation. Also this effect is generally concealed by accidental variations. It is not seen also in certain seas, although situated under the tropics, on account of the winds which the heat of the sun excites on the neighbouring lands. Such are the local and regular winds which are called monsoons in the Indian seas. In studying the laws of evaporation, it may be seen that a limited space, whether empty, or filled with any gas, cannot contain at every temperature but a certain quantity of water under the form of invisible vapour. But water may also exist in the air in another state under which it becomes visible, forming fogs and clouds. Then, according to the observations of Saussure, it appears that it is in hollow vesicles, sufficiently light to float freely in the air; and, indeed, as M. Laplace has very well observed, if the watery envelope be reduced to an extreme thinness, the capillary attraction which it exerts upon itself at its surface, must be infinitely weaker than in its ordinary state, and consequently it may also, by being less compressed, have a much less density. But it is very difficult to conceive what power can thus reunite and form, sometimes all at once in certain parts of space, collections of these particles so clearly limited as the clouds sometimes appear to be: and it is difficult to conceive how it is possible that the winds should bear them along without disuniting them. When watery vapours after having assumed this form, come nearer to each other and unite in liquid drops, they fall and form rain. If this precipitation be made at a sufficiently low temperature, the vapour freezes as it falls and becomes snow. A sufficiently great number of observations and plausible inductions, led Volta to think that hail is nothing else but drops of rain a long time tossed about at a low temperature between two electrical clouds in opposite directions. In general, the developement of electricity appears in a great number of circumstances to accompany, if not to cause, the precipitation of watery vapour. We do not absolutely know how this disengagement takes place; it is said that it never hails in winter, and that it never thunders when it snows; but more correct observation has shewn, that experience falsifies most of these assertions. According to an observation made in England, if two vessels of equal extent be exposed at different heights, and the quantity of water which falls into them during any considerable time, for instance, a year, be measured, it is found that the vessel at the greater height receives less water. This seems to point out that the drops of rain become larger as they fall by the precipitation of the watery vapours which they encounter; and that in lowering the temperature, of the space which they traverse, they cause these vapours to precipitate more abundantly. This experiment repeated at the Observatory at Paris, gave the same result. A necessary consequence is, that in general, more rain falls in the vallies than on the hills. I say in general, because experiment shews, sometimes, opposite results. The distribution of rain in the different seasons of the year varies according to the places, and according to the climates. The law of mean periods which this phenomena follows in each place, deserves to be observed by those who inhabit it, because it may afford them useful knowledge in conducting their agriculture. Detached clouds are sometimes seen to appear to descend in the form of a funnel, to the surface of the earth and of the sea. Commonly this phenomenon is caused by a column of air whirling round upon itself with considerable velocity as by the suction of Archimedes' screw, water, and even solid bodies. Often, lightning and thunder are seen to come out of these columns. If they pass a ship, they twist its sails and its masts, and make it whirl about. Sometimes they break and inundate with a deluge of water. Sailors, therefore, are much afraid of these meteors; and when they perceive them at a distance upon the sea, they attempt to break them by discharging cannon. It is very difficult, not to say impos-

sible, to ascertain precisely by the laws of mechanics only, how these terrible whirlwinds can be formed. It remains to give some particulars of a phenomenon which, perhaps has not the least connexion with the preceding, although usually classed with meteorology, we mean the aurora borealis. When this phenomenon is complete, it appears under the form of a luminous arc, or rather of the segment of a circle, situated on the side of the heavens towards the pole, and from which great radiations of light emanate at intervals, which, when they remain long enough to be seen several together, appear as arcs of great circles, which seem to meet at the same point of the heavens. The cause of this phenomenon is totally unknown, and can only be conjectured. It appears only, that it has a direct or indirect relation to the magnetism of the globe; for it is generally observed that when it takes place, the magnetic needle feels sudden and irregular agitations, which have been called wanderings. Besides, according to a very curious remark of Mr. Dalton, the summit of the arc seen from every place, seems directed in the magnetic meridian of that place. For Mr. Dalton observed this agreement in every aurora borealis, of which he saw a complete arc; and it is seen from the ancient observations of Maraldi, that it was the same in his time, although the direction of the magnetic meridian has considerably changed since that period. Lastly, an aurora borealis observed at Paris, February 1st, 1817, presented to M. Arago, exactly the same agreement. According to Mr. Dalton, the position of the point of concourse of the rays, should also have a constant relation with the direction of the magnetic forces, for it should correspond in each place to the direction of that resulting from these forces and the dip of the needle. There was no opportunity of observing this in the last aurora borealis at Paris, because the streams of light were not united. Be how it may, the coincidence only of the direction is very remarkable; and thus, as M. Arago judiciously notices, it must be according to this, that the aurora borealis is a phenomenon of position, like the rainbow, of which each sees his own apart, because otherwise the direction of the magnetic meridian being different in different places, and not conveying, like the meridians in the heavens, towards one point, it would not be possible that one object only should present itself to each observer following his own meridian. This particular, therefore, ought to be considered as one of the fundamental conditions which must be satisfied in any attempt made to explain the physical cause, why the aurora borealis is produced. This Mr. Dalton has attempted in a work entitled "Meteorological Observations." But notwithstanding the skill of this ingenious philosopher, it appears to us that the particulars of this phenomenon have not yet been sufficiently fixed to enable us to arrive at its real cause. It is not the north pole only, which offers these luminous appearances, they are observed, also, towards the south pole on advancing into the opposite hemisphere. This is, then, an aurora australis like the aurora borealis, and Cook often observed this phenomenon in his voyages. We shall conclude this summary of meteorology, by recommending an important application which has been made, of the laws of the geography of plants, to the measure of the mean heat of places. Every vegetable can live only in certain fixed limits of temperature, and the approach of these limits is marked by the vegetation becoming more or less drooping. The aspect of vegetables in every country, offers them a sort of living thermometer, which points out to the traveller the medium of the annual temperatures, and their extremes. We may see the principles of this useful application in the work of M. Humboldt, entitled "De Distributione Geographica Plantarum." And Mr. Van Buch made good use of it in his travels in Lapland.

MIASMATA. Vapours or effluvia which produce a baneful effect on the human frame, but of which the chemical nature is unknown.

MICA, derives its name from the Latin *micans*, glittering. It is known as the substance called Muscovy glass, and has a splendent lustre. It consists of very thin leaves or laminæ, which may be easily separated with a knife. The plates are elastic

by which it may be distinguished from the mineral called talc. The thin plates are transparent. The colours of the thick plates are yellow, grey, blackish green, white, and brown. The surface may be scratched with a knife: it melts into an enamel with the blow-pipe: it is rarely met with crystallized.

MICA-SLATE, consists of silica, mica, and oxide of iron.

MIEMITE, sub-species of dolomite.

MILK. This is a fluid secreted in the peculiar vessels of females of the human species, quadrupeds, and cetaceous animals, and destined for the purpose of nourishing their young. If left to spontaneous decomposition, passes through the vinous, acetous, and putrefactive fermentations. It yields, however, but little alcohol in this way. The Tartars, who obtain a spirit called koumiss from mares' milk, use large quantities of milk at a time, and agitate it frequently. To increase the fermentation, they add a sixth part of water, an eighth of the sourest cows' milk they can get, or a smaller portion of koumiss already prepared. They cover the vessel with a cloth, and let it stand twenty-four hours; then beat it with a stick; mix the thicker and thinner parts which have separated: they then let it stand other twenty-four hours in a narrower vessel, and repeat the beating till the liquor is perfectly homogeneous.—This liquor will keep well for some months in a close vessel, and in a cold place, but must be well beaten and shaken every time it is used. They sometimes extract a spirit from it by distillation The Arabs and the Turks prepare a similar liquor.—The saccharine substance, upon which the fermentation depends, remains in the whey after the curd is separated in making cheese. This is prepared in the large way in Switzerland, by evaporation, for medicinal purposes. When evaporated to the consistence of honey, it is poured in proper moulds, and exposed to dry in the sun. If this crude sugar of milk be dissolved in water, clarified with whites of eggs, and evaporated to the consistence of syrup, white crystals are obtained.—This sugar has a faint saccharine taste, is soluble in three or four parts of water, and yields by distillation the same products with other sugar. It contains an acid frequently called the saccho-lactic; and, as it is common to all mucilaginous bodies, is also called mucic acid.—In regard to the quantity of sugar contained, the different kinds of milk which have been examined, rank as follows:—mare's, woman's, ass's, goat's, sheep's, and cow's. As to quantity of whey, they rank:—ass's, mare's, woman's, cow's, goat's, sheep's.—As to cream:—sheep's, woman's, goat's, cow's, ass's, mare's.—As to butter:—sheep's, goat's, cow's, woman's.—As to cheese:—sheep's, goat's, cow's, ass's, woman's, mare's.—Cream of specific gravity, 1·024; according to Berzelius, consists of butter 4·5, cheese 3·5, whey 92.—Whey reddens vegetable blues from the presence of lactic acid.—One thousand parts of milk are said to consist of—

Curd - - - - -	28	—
Sugar of milk - - -	35	—
Muriate of potash - -	1	70
Phosphate of ditto - -	0	25
Lactic acid, acetate of potash, with a little lactic of iron	6	00
Water - - - - -	928	75
	1000	00

MILK QUARTZ.—See *Quartz*.

MINERALOGY, that branch of knowledge, the object of which is to describe, recognize, and classify, and explain the use of the different objects of inorganic matter. As the greater part of these are extracted from the earth by mining, they have been named minerals.

MINERALS. All mineral productions are comprehended in four classes; viz. the earthy, or the stones; the saline, or the salts; the inflammable, as sulphurs, &c.; and the metals, or metallic ores.

Every substance not possessing organization, or not the immediate product of some organized body, belongs to the mineral kingdom. Among the vast variety of minerals which demand the attention, and exercise the ingenuity of the chemist and the manufacturer, some are compounded in such principles, and formed under such circumstances and situations in the earth, as to be with difficulty distinguished, without recurring to the test of experiment. Others are formed with considerable regularity as to

the proportion of their principles, their colour, fracture, specific gravity, and crystallized figure.

The best system for the classification of minerals notices the external characters, and the component parts. The component parts or principles of minerals, afford the great outlines for classing them as species and varieties; and their external appearances, when not sufficiently decisive to the observer, will always point out the experiments by which to ascertain their place. The modern systems of Bergman, Kirwan, Chaptal, Schmeisser, and Babington, are founded on these considerations.

The system of Haüy has four classes. The first consists of substances composed of an acid united to an earth, or alkali, and sometimes to both. The second includes only earthy substances, sometimes combined with an alkali; it constitutes the siliceous genus of other systems. The third comprehends combustible substances, not metals. The metals form the fourth class, divided into three orders, characterized by their different degrees of oxydation. To these classes there are three appendices. The first contains those substances whose nature is not sufficiently known to have their places accurately assigned; the second, includes aggregates of different mineral substances; and the third is devoted to the consideration of volcanic products.

The system of Brongniart includes substances not treated of by writers on mineralogy; and has five classes. The first contains those substances (excluding the metals) combined with oxygen. It contains two orders; the first including air and water, and the second the acids. The second treats of saline bodies, and comprehends the alkaline and earthy salts. The third contains the hard, the magnesian, and the argillaceous stones. The fourth contains the combustible substances, compound and simple. The fifth includes metals, separated into the brittle and the ductile.

The system of Rome de Lisle has three classes; the first contains saline crystals; the second, stony crystals; and the third, metallic and semi-metallic crystals. He first directed the attention of mineralogists to the particular form of crystals, of which he enumerates the following species:—1. Tetraëdron. 2. Cube. 3. Octaëdron. 4. Parallelopiped. 5. Rhomboïdal octaëdron, and 6. Dodecaëdron, with triangular planes. He considered all minerals agreeing in crystallization, hardness, and specific gravity, as belonging to the same species.

The system of Werner is arranged, according to the characters of minerals, under four divisions: the external, the internal or chemical, the physical, and the empirical. To the first belong the external characters, drawn from properties obvious to the senses, as colour, lustre, transparency, form, texture, hardness, and specific gravity; to the second, those derived from the chemical composition, or discovered by any chemical change of the mineral; to the third are referred those characters afforded by certain physical properties, as electricity or magnetism; and to the fourth, a few characters derived from circumstances frequently observed with regard to the mineral, as the place where it is found, or the mineral by which it is usually accompanied.

MINERAL CAOUTCHOUC.—See *Caoutchouc*.

MINERAL CHARCOAL. — See *Charcoal*.

MOLYBDENUM. A metal which has not yet been reduced into masses of any magnitude; but has been obtained only in small separate globules, in a blackish brilliant mass. This may be effected by making its acid into a paste with oil, bedding it in charcoal in a crucible, and exposing it to an intense heat. The globules are grey, brittle, and extremely infusible. By heat it is converted into a white oxide, which rises in brilliant needle-formed flowers, like those of antimony. Nitric acid readily oxidizes and acidifies the metal. Nitre detonates with it, and the remaining alkali combines with its oxide. Molybdenum unites with several of the metals, and forms brittle or friable compounds. No acid acts on it but the nitric and nitromuriatic. Several acids act on its oxide, and afford blue solutions.

MOLYBDIC ACID. If the native

sulphuret of molybdenum be roasted for some time, and then dissolved in liquid ammonia, and nitric acid be added to the solution, fine white scales will be precipitated, which are the molybdic acid. They become yellow by melting and sublimation. This acid has not yet been applied to any useful purpose.

MOLYBDOUS ACID, consists of 100 molybdenum and 34 oxygen.

MONTMARTRITE, consists of 83 sulphate of lime, and 17 carbonate of lime. It is found at Montmartre, near Paris.

MOONSTONE, a variety of adularia.

MOORCOAL.—See *Coal.*

MORASS ORE, a species of iron ore.

MOROXYLATES, compounds of the moroxylic acid and salifiable bases.

MOROXYLIC ACID. A saline substance on the trunk of a white mulberry tree was analysed, and supposed to contain a peculiar acid; and it provisionally is thus named until farther researches be made on the subject.

MORPHIA, a new vegetable alkali, extracted from opium, of which it constitutes the narcotic principle. If taken into the stomach it has very violent effects.

MORTAR CEMENT, a mixture of lime and siliceous sand, used in masonry for cementing together the stones and bricks of a building.

MOSAIC GOLD.—See *Aurum Musivum.*

MOTHER OF PEARL shells are composed of alternate layers of coagulated albumen and carbonate of lime, in the proportion, by Mr. Hatchett, of 24 of the former and 76 of the latter, in 100 parts.

MOTHER WATER. When sea-water is evaporated and salt taken out, there always remains a fluid containing deliquescent salts, and the impurities, if present. This is called the mother water.

MOULD.—See *Soil, Manure, and Analysis (Vegetable).*

MOUNTAIN BLUE. Malachite; carbonate of copper.

MOUNTAIN CORK and MOUNTAIN LEATHER.—See *Asbestus.*

MOUNTAIN GREEN. Common copper green; a carbonate of copper.

MOUNTAIN or ROCK WOOD.—See *Asbestus.*

MOUNTAIN SOAP, is a mineral, used in crayon painting. It is found in the Isle of Sky. It writes, but does not soil.

MOUNTAINS, (changes of). The diminution of rocks and mountains is constantly taking place by the incessant operations of the elements, until the loftiest eminences are reduced and covered with soil and vegetables, which protect them from further decay. Instances have occurred of whole mountains suddenly falling down, and burying the inhabitants of the vales below under their ruins. In the Alps the process of disintegration is rapidly going on; but such is the immensity of these enormous mountains, that ages pass away before any diminution of their bulk is perceived. That the mountains of our island have once been much higher than at present, is evident to every one who has attentively examined them. The rocky fragments in Borrowdale, the deep ravines made by torrents in the sides of Skiddaw, and the scattered rocks at the foot of Snowdon, offer striking proofs of this. The central parts of England have also once had a greater elevation. The white quartz pebbles spread over the midland counties are the remains of the decomposed hills in Charnwood forest, or of others connected with them which are now worn down. Beacon Hill, one of the highest points of this range, does not rise more than 760 feet above the surrounding country; but all these hills are evidently the remains of a more lofty and extended chain of mountains. Large blocks of white quartz lie upon their summits, which once formed veins intersecting higher rocks; this quartz being harder, has remained after the other parts were worn down. Veins filled with similar quartz may be traced near the places where these blocks lie. Beside the destructive effects of mountain torrents, so sudden and impetuous in Alpine countries, there is another powerful agent in nature that can rend the hardest rocks, and to which mountains that contain much metallic matter are particularly exposed; this is lightning. The ancients, whose views of external nature were al-

most always correct, have described the destruction of rocks and mountains as a characteristic phenomenon attending thunder-storms. It is, however, to the more constant operation of moisture and change of temperature, that the disintegration of rocks and mountains may be principally attributed; but no well authenticated observations have yet been made to determine the extent of these effects in certain periods of time. It has been vaguely stated that the height of the Pyrennees is diminishing one foot in a century; hence it was calculated that more than a million of years would be required to level the boundary which separates France and Spain. There are, however, agents in nature, earthquakes, volcanoes, and perhaps central subterranean fire, that can entomb whole continents in the ocean, and raise mountains from the watery abyss in a single night. Evident indications exist that such causes have operated extensively on the surface of our planet; but the periods of time in which they are destined to succeed each other, remain beyond the power of human sagacity to determine. By the slow but constant destruction of rocks and mountains, new and productive soils are formed to renovate the surface of the globe, and prepare it for the support of animal life; this appears to be the final cause for which the world was created, and to which all terrestrial changes ultimately refer. It has been justly observed by Dr. Paley and others, that in the peculiar conformation of the teeth in graminivorous animals, and in the production of grasses which serve them for food, we may trace evident marks of relation, and of a designing intelligent cause; with equal reason must we admit that the destruction of mountains, and the formation of soils for the support of the vegetable tribes, are provided for by the same cause, and are part of a regular series of operations in the economy of nature: hence also we may infer, that those grand revolutions of the globe, by which new mountains or continents are elevated from the deep, are parts of the same series, extending through ages of endless duration, and connecting in one chain all the successive phenomena of the material universe. Besides the gradual decomposition of mountains, they sometimes present the sudden changes of a fall or avalanche. These are terrible phenomena, which unfortunately are not uncommon in Switzerland, and are likely to occur in all vast and numerous mountains that are stratified, the strata lying generally at so high an angle of inclination, as to be extremely likely to slip, when any of the softer ones which are interposed are so far disintegrated or lubricated by the water, as no longer to adhere firmly to the upper portion, but allow it to slip down the inclined plane on which it rests. The most extensive catastrophe of this kind that has occurred of late years, took place in 1806, in the mountain of Rossberg, when a space twice as large as the city of Paris slipped down at once into the lake of Lawertz, and occasioned the most dreadful devastation. This mountain was composed of parallel strata of pudding-stone, separated in many places by thin beds of argillaceous earth, liable to be turned, by the introduction of water, into a smooth slippery mud, and over the highly inclined bed of which the upper strata would slide, just as a ship in the act of launching slides in her ways. The following are some of the interesting particulars of this catastrophe. The summer of 1806 had been very rainy, and on the 1st and 2d of September it rained incessantly. New crevices were observed in the flank of the mountain; a sort of cracking noise was heard internally; stones started out of the ground; detached fragments of rock rolled down the mountain. At two o'clock in the afternoon of the 2d of September, a large rock became loose, and in falling raised a cloud of dust. Towards the lower part of the mountain, the ground seemed pressed down from above, and when a stick or a spade was driven in, it moved of itself. Soon a fissure larger than all the others was observed; insensibly it increased. Springs of water ceased all at once to flow; the pine-trees of the forest absolutely reeled; birds flew away screaming. A few minutes before five o'clock, the whole surface of the mountain seemed to glide down, but so slowly as to afford time to the inhabitants to get away. At last it

precipitated itself, and such a mass of earth and stones rushed at once into the lake of Lawertz, although five miles distant, that one end of it was filled up, and a prodigious wave passing completely over the island of Schwanau, seventy feet above the usual level of the water, overwhelmed the opposite shore, and as it returned, swept away into the lake many houses of the inhabitants. Another accident of the same kind occurred in 1801, on the lake of Lucerne, when eleven persons were drowned at a village on the opposite side of the lake, by a wave raised by a falling mass. A more tremendous calamity was threatened by the mountain Righi, in 1795, near the same lake. In the spring of that year, longitudinal cracks or crevices appeared in the perpendicular front of the Righi. Before day on the 16th of July, the inhabitants were awakened by strange noises, and soon observed a stream of mud, a mile wide, and fifty or sixty feet high, coming down upon them; but as it travelled very slowly, they had time to take care of their moveables. Like a stream of lava it overtopped and crushed down houses, walls, and every artificial obstacle in its way, and flowing during a whole fortnight, covered a great part of the country with a bed of ferruginous clay, which the long application of industrious labour is only beginning to render productive. Doubtless, this clay intervening between strata of rock, and softened by the accidental introduction of springs, was pressed out by the superincumbent weight of 2000 or 3000 perpendicular feet of mountain. The earthy stratum being thus removed, it is to be hoped that all danger of the fall of the Righi is removed.

MUCIC ACID. This acid has been generally known by the name of *saccholactic*, because it was first obtained from sugar of milk; but as all the gums appear to afford it, and the principal acid in sugar of milk is the oxalic, chemists in general now distinguish it by the name of mucic acid. It was discovered by Scheele. Having poured twelve ounces of diluted nitric acid on four ounces of powdered sugar of milk, in a glass retort on a sand bath, the mixture became gradually hot, and at length effervesced violently, and continued to do so for a considerable time after the retort was taken from the fire. It is necessary therefore to use a large retort, and not to lute the receiver too tight. The effervescence having nearly subsided, the retort was again placed on the sand heat, and the nitric acid distilled off, till the mass had acquired a yellowish colour. This exhibiting no crystals, eight ounces more of the same acid were added, and the distillation repeated till the yellow colour of the fluid disappeared. As the fluid was inspissated by cooling, it was re-dissolved in eight ounces of water, and filtered. The filtered liquor held oxalic acid in solution, and seven drachms and a half of white powder remained on the filter. This powder was the acid under consideration. If one part of gum be heated gently with two of nitric acid, till a small quantity of nitrous gas and of carbonic acid is disengaged, the dissolved mass will deposit on cooling the mucic acid. According to Fourcroy and Vauquelin, different gums yield from 14 to 26 hundredths of this acid. This pulverulent acid is soluble in about 60 parts of hot water, and by cooling, a fourth part separates in small shining scales, that grow white in the air. It decomposes the muriate of barytes, and both the nitrate and muriate of lime. It acts very little on the metals, but forms with their oxides salts scarcely soluble. It precipitates the nitrates of silver, lead, and mercury. With potash it forms a salt soluble in eight parts of boiling water, and crystallizeable by cooling. That of soda requires but five parts of water, and is equally crystallizable. Both these salts are still more soluble when the acid is in excess. That of ammonia is deprived of its base by heat. The salts of barytes, lime, and magnesia, are nearly insolubie

MUCILAGE, must be considered as a variety of gum. It agrees with it in most of its important properties, but seems to have less attraction for water. When gum and mucilage are dissolved together in water, mucilage may be separated by means of sulphuric acid. Mucilage may be procured from linseed, from the bulbs of hyacinth, from the leaves of marsh mallows, from several of the lichens,

and other vegetable substances. Gum arabic, according to MM. Gay, Lussac, and Henard, contains

Carbon,	42·23
Oxygen,	50·84
Hydrogen,	6·93
	100·00

All the varieties of gum and mucilage are nutritious as food. They are employed in some of the arts, particularly calico-printing. Till lately, in this country, the calico-printers used gum arabic, but many of them, at the suggestion of Lord Dundonald, now employ the mucilage from lichens.

MUCUS. This, according to Dr. Bostock, is one of the primary animal fluids, perfectly distinct from gelatine. The subacetate of lead does not affect gelatin; on the other hand, tannin, which is a delicate test of gelatin, does not affect mucus. Both these re agents, however, precipitate albumen; but the oxymuriate of mercury, which will indicate the presence of albumen dissolved in 2000 parts of water, precipitates neither mucus nor gelatin. Thus we have three distinct and delicate tests for these three different principles. Gum appears to resemble mucus in its properties. One grain of gum arabic, dissolved in 200 of water, was not affected by oxymuriate of mercury, or by tannin, but was immediately precipitated by subacetate of lead.

MUFFLE. A small earthen oven, made and sold by the crucible manufacturers. It is to be fixed in a furnace, and is useful for cupellation, and other processes which demand access of air.

MURIACITE. Gypsum.

MURIATES. Compounds of the muriatic acid, and acidifiable bases.

MURIATIC ACID. When equal volumes of hydrogen and chlorine gases are mixed and exposed to light, they combine and produce a sour compound commonly called muriatic acid gas, or in conformity to more modern nomenclature, hydrochloric acid gas. The best mode of shewing the composition of muriatic acid, is to introduce into a small but strong glass vessel, a mixture of the two gases, and to inflame them by the electric spark, no change of volume ensues, and muriatic gas results. Muriatic acid may be decomposed by the action of several of the metals. Potassium, for instance, absorbs the chlorine, and the hydrogen is evolved and muriatic acid gas thus affords half its volume of hydrogen. Muriatic acid may also readily be procured by acting upon common salt by sulphuric acid, the evolved gas must be received over mercury. It was first obtained pure by Dr. Priestly, but its composition was discovered by Scheele, and has since been most ably investigated by Davy. Muriatic acid gas extinguishes flame. Its specific gravity, compared with hydrogen, is = 17·25. 100 cubic inches = 39·5 grains. Muriatic acid gas is greedily absorbed by water, which takes up 480 times its bulk, and has its specific gravity increased from 1. to 1·210. Thus dissolved in water, it forms the liquid muriatic acid or spirit of salt, and may easily be procured by distilling a mixture of dilute sulphuric acid and common salt, as directed in the London Pharmacopœia. The most economical proportions, are 32 parts of salt and 22 of sulphuric acid diluted with one-third its weight of water. The retort containing these ingredients, may be luted on to a receiver containing twice the quantity of water used in diluting the sulphuric acid, and the distillation carried on in a sand-bath. When the liquid acid is pure, it is perfectly colourless, but it generally has a yellow hue arising from a little iron. When heated the gaseous acid is evolved. The English manufacturers use iron stills for this distillation, with earthen heads: the philosophical chemist, in making the acid of commerce, will, doubtless, prefer glass. Five parts, by weight, of strong sulphuric acid are to be added to six of decrepitated sea salt, in a retort, the upper part of which is furnished with a tube or neck, through which the acid is to be poured upon the salt. The aperture of this tube must be closed with a ground stopper immediately after the pouring. The sulphuric acid immediately combines with the alkali, and expels the muriatic acid in the form of a peculiar air, which is rapidly absorbed by water. As this combination and disengagement takes place without the application of heat, and the aerial fluid escapes very rapidly,

it is necessary to arrange and lute the vessels together before the sulphuric acid is added, and not to make any fire in the furnace until the disengagement begins to slacken; at which time it must be very gradually raised. Before the modern improvements in chemistry were made, a great part of the acid escaped for want of water to combine with: but by the use of Woolfe's apparatus, in the process, the acid air is made to pass through water, in which it is nearly condensed, and forms muriatic acid of double the weight of the water, though the bulk of this fluid is increased one-half only. The acid condensed in the first receiver, which contains no water, is of a yellow colour, arising from the impurities of the salt. The marine acid in commerce has a straw colour: but this is owing to accidental impurity; for it does not obtain in the acid produced by the impregnation of water with the aëriform acid. The muriatic acid is one of those longest known, and some of its compounds are among those salts with which we are most familiar. The muriates, when in a state of dryness, are actually chlorides, consisting of chlorine and the metal; but moisture makes them instantly pass to the state of muriates. The *muriate of barytes* crystallizes in tables bevelled at the edges, or in octaëdral pyramids applied base to base. It is soluble in five parts of water at 60 deg., in still less at a boiling heat, and also in alcohol. It is not altered in the air, and but partly decomposable by heat. The sulphuric acid separates its base; and the alkaline carbonates and sulphates decompose it by double affinity. It is best prepared by dissolving the carbonate in dilute muriatic acid; and if contaminated with iron or lead, which occasionally happens, these may be separated by the addition of a small quantity of liquid ammonia, or by boiling and stirring the solution with a little barytes. Mr. Goettling recommends to prepare it from the sulphate of barytes: eight parts of which, in fine powder, are to be mixed with two of muriate of soda, and one of charcoal powder. This is to be pressed hard into a Hessian crucible, and exposed for an hour and a half to a red heat in a wind furnace. The cold mass, being powdered, is to be boiled a minute or two in sixteen parts of water, and then filtered. To this liquor muriatic acid is to be added by little and little, till sulphuretted hydrogen ceases to be evolved; it is then to be filtered, a little hot water to be poured on the residuum, the liquor evaporated to a pellicle, filtered again, and then set to crystallize. As the muriate of soda is much more soluble than the muriate of barytes, and does not separate by cooling, the muriate of barytes will crystallize into a perfectly white salt, and leave the muriate of soda in the mother water, which may be evaporated repeatedly till no more muriate of barytes is obtained. This salt was first employed in medicine by Dr. Crawford, chiefly in scrofulous complaints and cancer, beginning with doses of a few drops of the saturated solution twice a-day, and increasing it gradually, as far as forty or fifty drops in some instances. In large doses it excites nausea, and has deleterious effects. Fourcroy says it has been found very successful in scrofula in France. It has likewise been recommended as a vermifuge; and it has been given with much apparent advantage, even to very young children, where the usual symptoms of worms occurred, though none were ascertained to be present. As a test of sulphuric acid it is of great use. The *muriate af potash*, formerly known by the names of febrifuge salt of Sylvius, digestive salt, and regenerated sea salt, crystallizes in regular cubes, or in rectangular parallelopipedons; decrepitating on the fire, without losing much of their acid, and acquiring a little moisture from damp air, and giving it out again in dry. Their taste is saline and bitter. They are soluble in thrice their weight of cold water, and in but little less of boiling water, so as to require spontaneous evaporation for crystallizing. Fourcroy recommends, to cover the vessel with gauze, and suspend hairs in it, for the purpose of obtaining regular crystals. It is sometimes prepared in decomposing sea salt by common potash for the purpose of obtaining soda; and may be formed by the direct combination of its constituent parts. It is decomposable by the sul-

phuric and nitric acids. Barytes decomposes it, though not completely. And both silex and alumina decomposed it partially in the dry way. It decomposes the earthy nitrates, so that it might be used in saltpetre manufactories to decompose the nitrate of lime. *Muriate of soda*, or common salt, is of considerable use in the arts, as well as a necessary ingredient in our food. It crystallizes in cubes, which are sometimes grouped together in various ways, and not unfrequently form hollow quadrangular pyramids. In the fire it decrepitates, melts, and is at length volatilized. When pure it is not deliquescent. One part is soluble in 2½ of cold water, and in little less of hot, so that it cannot be crystallized but by evaporation. According to M. Chenevix, it is soluble in alcohol also, particularly when it is mixed with the chlorate. Common salt is found in large masses, or in rocks under the earth, in England and elsewhere. In the solid form it is called sal gem or rock salt. If it be pure and transparent, it may be immediately used in the state in which it is found; but if it contain any impure earthy particles, it should be previously freed from them. In some countries it is found in incredible quantities, and dug up like metals from the bowels of the earth. In this manner has this salt been dug out of the celebrated salt mines near Bochnia and Wieliczka, in Poland, ever since the middle of the 13th century, consequently above these 500 years, in such amazing quantities, that sometimes there have been 20,000 tons ready for sale. In these mines, which are said to reach to the depth of several hundred fathoms, 500 men are constantly employed. The pure and transparent salt needs no other prepartion than to be beaten to small pieces, or ground in a mill. But that which is more impure must be elutriated, purified, and boiled. That which is quite impure, and full of small stones, is sold under the name of rock salt, and is applied to ordinary uses; it may likewise be used for strengthening weak and poor brine-springs. Though the salt mines of Wieliczka, near Cracow in Poland, have long astonished the philosopher and the traveller, yet it deserves to be remarked, that the quantity of rock salt obtained from the mines of Northwich, is greatly superior to that obtained at Cracow. The bishop of Llandaff affirms, that a single pit, into which he descended, yielded at a medium 4000 tons of salt in a year, which alone is about two-thirds of that raised in the Polish mines. This rock salt is never used on our tables in its crude state, as the Polish rock salt is; and though the pure transparent salt might be used with our food, without any danger, yet it is prohibited under a penalty of 40s. for every pound of rock salt so applied. It is partly purified in water, and a great part of it is sent to Liverpool and other places, where it is used either for strengthening brine-springs or sea water. Beside the salt mines here mentioned, where the common salt is found in a concrete state, under the name of rock salt, there is at Cordova, in the province of Catalonia in Spain, a remarkable solid mountain of rock salt: this mountain is between four and five hundred feet in height, and a league in circuit; its depth below the surface of the earth is not known. This mountain contains the rock salt without the least admixture of any other matter. The waters of the ocean, every where, abound with common salt, though in different proportions. The water of the Baltic sea is said to contain one sixty-fourth of its weight of salt; that of the sea between England and Flanders contains one thirty-second part: and that on the coast of Spain, one sixteenth part; and between the tropics it is said, erroneously, to contain from an eleventh to an eighth part. The water of the sea contains, besides the common salt, a considerable proportion of muriate of magnesia, and some sulphate of lime, of soda, and potash. The former is the chief ingredient of the remaining liquid which is left after the extraction of the common salt, and is called the mother water. Sea water, if taken up near the surface, contains also the putrid remains of animal substances, which render it nauseous, and in a long continued calm, cause the sea to stink. The whole art of extracting salt from waters which contain it, consists in evaporating the water in the cheapest and most convenient manner. In

England, a brine composed of sea water, with the addition of rock salt, is evaporated in large shallow iron boilers; and the crystals of salt are taken out in baskets. In Russia, and probably in other northern countries, the sea water is exposed to freeze; and the ice, which is almost entirely fresh, being taken out, the remaining brine is much stronger, and is evaporated by boiling. In the southern parts of Europe the salt-makers take advantage of spontaneous evaporation. A flat piece of ground near the sea is chosen, and banked round, to prevent its being overflowed at high water. The space within the banks is divided by low walls into several compartments, which successively communicated with each other. At flood tide, the first of these is filled with sea water; which, by remaining a certain time, deposits its impurities and loses part of its aqueous fluid. The residue is then suffered to run into the next compartment; and the former is again filled as before. From the second compartment, after a due time, the water is transferred into a third, which is lined with clay, well rammed and levelled. At this period the evaporation is usually brought to that degree, that a crust of salt is formed on the surface of the water, which the workmen break, and it immediately falls to the bottom. They continue to do this, until the quantity is sufficient to be raked out, and dried in heaps. This is called bay salt. In some parts of France, and also on the coast of China, they wash the dried sands of the sea with a small proportion of water, and evaporate this brine in leaden boilers. There is no difference between this salt and the lake salt extracted from different lakes, excepting such as may be occasioned by the casual intervention of some substances. In this respect the Jeltonic salt water lake, in the Russian dominions, near Saratow Dmitrewsk, deserves our attention. In the year 1748, when the Russians first fetched salt thence, the lake was almost solid with salt; and that to such a degree, that they drove their heavy waggons over it, as over a frozen river, and broke up the salt. But since the year 1757, the water has increased so much, that at this time it is nothing more than a lake very strongly impregnated with salt. The Jeltonic lake salt contains at the same time alum and sulphate of magnesia. At several places in Germany, and at Montmarot in France, the waters of salt springs are pumped up to a large reservoir at the top of a building or shed: from which it drops or trickles through small apertures upon boards covered with brush-wood. The large surface of the water thus exposed to the air, causes a very considerable evaporation; and the brine is afterwards conveyed to the boilers for the perfect separation of the salt. To free common salt from those mixtures that render it deliquescent, and less fit for the purposes to which it is applied, it may be put into a conical vessel with a small aperture at the point, and saturated solution of the muriate of soda boiling hot be poured on it. This solution will dissolve and carry off any other salts mixed with the soda, and leave it quite pure, by repeating the process three or four times. The process of Scheele, which consists in mixing the muriate of soda with red oxide of lead, making this into a soft paste with water, and allowing it to stand thus for some time, moistening it with water as it gets dry, and then separating the soda from the muriate of lead by lixiviation, has been resorted to in this country. Mr. Turner some years ago had a patent for it; converting the muriate of lead into a pigment, which was termed *mineral* or *patent yellow*, by heating it to fusion. The oxide of lead should be at least twice the weight of the salt. This would have answered extremely well, had there been an adequate and regular demand for the pigment. At present, the greater part of the carbonate of soda in the market is furnished by decomposing the sulphate of soda left after the muriatic acid is expelled in the usual way of manufacturing it from common salt. Various processes for this purpose were tried in France, and made public by the French government, all depending on the principle of decomposing the acid of the sulphate, by charcoal, and at the same time adding some other material to prevent the soda from forming a sulphuret. What they consider as the best, is to mix the sulphate of soda with an equal weight

of chalk, and rather more than half its weight of charcoal powder, and to expose the mixture in a reverberatory furnace to a heat sufficient to bring them to a state of imperfect liquefaction. Much of the sulphur formed will be expelled in vapour and burned, the mixture being frequently stirred to promote this; and this is continued till the mass on cooling assumes a fine grain. It is then left exposed to a humid atmosphere, and the carbonate of soda may be extracted by lixiviation, the sulphur not consumed having united with the lime. Tinmen's sheds, or old iron, may be employed instead of chalk, in the proportion of 65 parts to 200 of sulphate of soda, and 62 of charcoal; or chalk and iron may be used at the same time in different proportions. The muriate of soda might be decomposed in the first instance by the sulphate of iron, instead of the sulphuric acid. The carbonate of soda thus prepared, however, is not free from sulphur, and Dizé recommends the abstraction of it by adding litharge to the lixivium in a state of ebullition, which will render the alkali pure. Oxide of manganese was substituted in the same way with equal success: and this may be used repeatedly, merely by calcining it after each time to expel the sulphur. Mr. Accum gives the following method, as having answered extremely well in a soda manufactory in which he was employed;—Five hundred pounds of sulphate of soda, procured from the bleachers, who make a large quantity in preparing their muriatic acid from common salt, were put into an iron boiler with a sufficient quantity of soft water. Into another boiler were put 560 lbs. of good American potash, or 570 if the potash were indifferent, dissolved in about 30 pails of water, or as little as possible. When both were brought to boil, the solution of potash was ladled into that of sulphate of soda, agitating the mixture, and raising the fire as quickly as possible. When the whole boiled, it was ladled into a wooden gutter, that conveyed it to a wooden cistern lined with lead near half an inch thick, in a cool place. Sticks were placed across the cistern, from which slips of sheet lead, two or three inches wide, hung down into the fluid about four inches distant from each other. When the whole was cold, which in winter was in about three days, the fluid was drawn off, the crystallized salt was detached from the slips of lead, and the rock of salt fixed to the bottom was separated by a chisel and a mallet. The salt being washed in the same cistern, to free it from impurities, was then returned to the boiler, dissolved in clear water, and evaporated till a strong pellicle formed. Letting it cool till the hand could be dipped into it, it was kept at this temperature as long as pellicles would form over the whole surface, and fall to the bottom. When no more pellicles appeared without blowing on the surface, the fire was put out, and the solution returned into the cistern to crystallize. If the solution be suffered to cool, pretty low, very little sulphate of potash will be found mixed with the soda; but the rocky masses met with in the market generally contain a pretty large quantity. In the process above described, the produce of the mixed salt from 100 lbs. of sulphate of soda was in general from 136 to 139 lbs. Beside its use in seasoning our food, and preserving meat both for domestic consumption and during the longest voyages, and in furnishing us with the muriatic acid and soda, salt forms a glaze for coarse pottery, by being thrown into the oven where it is baked; it improves the whiteness and clearness of glass; it gives greater hardness to soap; in melting metals it preserves their surface from calcination, by defending them from the air, and is employed with advantage in some assays; it is used as a mordant, and for improving certain colours; and it also enters more or less into many other processes of the arts. The *muriate of strontian* has not long been known. Dr. Hope first distinguished it from muriate of barytes. It crystallizes in very slender hexagonal prisms, has a cool pungent taste, without the austerity of the muriate of barytes, or the bitterness of the muriate of lime; is soluble in 0·75 of water at 60 deg. and to almost any amount in boiling water; is likewise soluble in alcohol, and gives a blood-red colour to its

flame. It has never been found in nature, but may be prepared in the same way as the muriate of barytes. The *muriate of lime* has been known by the names of *marine selenite*, *calcareous marine salt*, *muria*, and *fixed sal ammoniac*. It crystallizes in hexaëdral prisms, terminated by acute pyramids; but if the solution be greatly concentrated, and exposed to a low temperature, it is condensed in confused bundles of needly crystals. Its taste is acrid, bitter, and very disagreeable. It is soluble in half its weight of cold water, and by heat in its own water of crystallization. It is one of the most deliquescent salts known; and when deliquesced has been called *oil of lime*. It exists in nature, but neither very abundantly nor very pure. It is formed in chemical laboratories, in the decomposition of muriate of ammonia; and Homberg found, that, if it were urged by a violent heat till it condensed, on cooling, into a vitreous mass, it emitted a phosphoric light upon being struck by any hard body, in which state it was called *Homberg's phosphorus*. Hitherto it has been little used, except for frigorific mixtures; and with snow it produces a very great degree of cold. Fourcroy, indeed, says he has found it of great utility in obstructions of the lymphatics, and in scrofulous affections. The *muriate of ammonia* has long been known by the name of *sal ammonia*, or *ammoniac*. It is found native in the neighbourhood of volcanoes, where it is sublimed sometimes nearly pure, and in different parts of Asia and Africa. A great deal is carried annually to Russia and Siberia from Bucharian Tartary; and we formerly imported large quantities from Egypt, but now manufacture it at home. See *Ammonia*. This salt is usually in the form of cakes, with a convex surface on one side, and concave on the other, from being sublimed into large globular vessels; but by solution it may be obtained in regular quadrangular crystals. It is remarkable for possessing a certain degree of ductility, so that it is not easily pulverable. It is soluble in 3¼ parts of water at 60°, and in little more than its own weight of boiling water. Its taste is cool, acrid, and bitterish. Its specific gravity is 1·42. It attracts moisture from the air but very slightly. *Muriate of ammonia* has been more employed in medicine than it is at present. It is sometimes useful as an auxiliary to the bark in intermittents; in gargles it is beneficial, and externally it is a good discutient. In dying it improves or heightens different colours. In tinning and soldering it is employed to preserve the surface of the metals from oxidation. In assaying it discovers iron, and separates it from some of its combinations. The muriate of magnesia is extremely deliquescent, soluble in an equal weight of water, and difficultly crystallizable. It dissolves also in five parts of alcohol. It is decomposable by heat, which expels its acid. Its taste is intensely bitter. With ammonia this muriate forms a triple salt, crystallizable in little polyedrons which separate quickly from the water, but are not very regularly formed. Its taste partakes of that of both the preceding salts. The best mode of preparing it is by mixing a solution of 27 parts of muriate of ammonia with a solution of 73 of muriate of magnesia; but it may be formed by a semi-decomposition of either of these muriates by the base of the other. It is decomposable by heat, and requires six or seven times its weight of water to dissolve it. Of the muriate of glucine we know but little. It appears to crystallize in very small crystals; to be decomposable by heat; and dissolved in alcohol and diluted with water, to form a pleasant saccharine liquor. Muriate of alumina is scarcely crystallizable, as on evaporation it assumes the state of a thick jelly. It has an acid, styptic, acrid taste, it is extremely soluble in water, and deliquescent. Fire decomposes it. It may be prepared by directly combining the muriatic acid with alumine, but the acid always remains in excess. The muriate of zircon crystallizes in small needles, which are very soluble, attract moisture, and lose their transparency in the air. It has an austere taste, with somewhat of acrimony. It is decomposable by heat. The gallic acid precipitates from its solution, if it be free from iron, a white powder. Carbonate of ammonia, if added in excess, re-dis-

solves the precipitate it had before thrown down. Muriate of yttria does not crystallize when evaporated, but forms a jelly; it dries with difficulty, and deliquesces. Fourcroy observes, that when siliceous stones, previously fused with potash, are treated with muriatic acid, a limpid solution is formed, which may be reduced to a transparent jelly by slow evaporation. But a boiling heat decomposes the siliceous muriate, and the earth is deposited. The solution is always acid.

MURI-CALCITE, is another name for Rhomb-Spar.

MUSCLES of animals, consist of fibrin and flesh.

MUSCOVY GLASS is a name given to mica, from the circumstance of its being used by the Russians for glass.

MUSHROOMS. See *Boletus*.

MUST, the juice of grape, composed of water, sugar, jelly, gluten, and bitartrate of potash.

MYRICIN, the ingredient of wax, after digestion with alcohol.

MYRRH, a gum resin, containing, according to Braconnot—

Resin, with some volatile oil	33·68
Gum	66·32

N.

NACRITE.—See *Talcite.*

NADELSTEIN. Rutile.

NAILS are found to be composed of coagulated albumen with phosphate of lime.

NAPTHA, is a native combustible liquid which differs from petroleum, which is obtained by the distillation of coals in being purer and lighter. It is found abundantly near the Caspian Sea, and in some places in Italy and Sicily, and is burnt as oil.

NAPLES YELLOW, is obtained from calcining lead with antimony and potass.

NARCOTIC PRINCIPLE OF VEGETABLES, is found abundantly in opium, which is obtained from the juice of the white poppy. To procure the narcotic principle, water is digested upon opium; the solution obtained is evaporated till it becomes of the consistence of a syrup. By the addition of cold water to this syrup, a precipitate is obtained. Alcohol is boiled in this precipitate, and during the cooling the crystals fall down. These are to be dissolved in alcohol, and again precipitated in cooling; and the process is to be repeated till their colour is white. They are crystals of the narcotic principle. The narcotic principle has no taste or smell. It is insoluble in cold water, but is soluble in 400 parts of boiling water. It is soluble in 24 parts of boiling alcohol and 100 parts of cold alcohol. It is very soluble in all acid menstruums. It has been shown by De Rosne, that the action of opium on the animal economy, depends on this principle Many other vegetable substances possess narcotic properties. The garden lettuce (lactuca sativa), and most other plants of that genus, yield a milky juice, which, when inspissated, has the characters of opium, and probably contains the same narcotic principle.

NATRON, native carbonate of soda. It is found in vast abundance in the lakes near Alexandria, in Egypt. The existence of natron in the midst of plains, in the waters of marshes and lakes which cover them, is one of the most interesting facts in geology. We find this phenomenon every where in the midst of vast deserts, which occur in so many places of our globe. From all that we know of this mineral production in Egypt, Arabia, Persia, India, Thebet, China, Siberia, the plains near the Caspian and Black Seas, in Asia Minor, in Hungary, and at Mexico, we have reason to believe that it occurs in the same circumstances and with the same relations. It is found every where, in the midst of sands, mixed with clay and marl, and accompanied with other salts, of which common salt is the most constant. In warm weather the natron is constantly efflorescing at the surface of the soil. The origin of this natron cannot with certainty be determined. The opinion which will most naturally present itself is, that natron occurs already formed in the sand or clay at a certain depth, along with the different salts with which it is mixed, and that the waters, by filtering

through the mass of earth in order to regain their level, laid hold of those substances, which they carried to the surface of the soil. This opinion, however, cannot be supported by any positive observation, because no pits have been dug which confirm it in the different places where natron appears at the surface. So also, nowhere in the deposits of rock-salt, is carbonate of soda found; and the waters of the sea are equally destitute of it. Nevertheless, on the sea-shore, natron is formed, though in small quantity, efflorescing at the surface; and here its origin must be attributed to the decomposition of the muriate of soda. This decomposition may be effected in various ways, and advantage is taken of this in the manufacture of artificial subcarbonate of soda, in which several methods, more or less perfect, have been successfully employed. It is probable, therefore, that it is from the natural decomposition of muriate of soda, that natron is formed. The natron in Egypt, in the opinion of M. Berthollet, is produced by the reciprocal action of muriate of soda and carbonate of lime, assisted by efflorescence. The lakes of Egypt contain a great quantity of muriate of soda, and they occur in the midst of a calcareous formation, the rocks of which project here and there through the sand which covers them. Masses, or beds of gypsum, also occur, which probably accompany the deposits of rock-salt which the waters traverse before arriving at the lakes. The same explanation will probably be found to be applicable to many other instances of the formation of natron, or mineral carbonate of soda.

NATROLITE, a sub-species of prismatic zeolite.

NEEDLE ORE, an ore of bismuth.

NEEDLE ZEOLITE, consists of silica, 50·24; alumina, 29·3; lime, 9·46; water 10.

NEPHELINE, rhomboidal felspar.

NEPHRITE, consists of silica, 50·5; magnesia, 31; alumina, 10; iron, 5·5; water, 2·75; with a minute portion of chromum. There is a kind of nephrite called axe-stone, which see.

NEPTUNIAN THEORY IN GEOLOGY, is that which endeavours to account for the various geological phenomena on the supposition that the matter of which the exterior part of the earth is composed, was once in a state of watery solution. Its chief supporter is Werner. It is opposed to the Plutonic or Vulcanic theory, which supposes the phenomena to have resulted from the matter of the earth having been in a state of fusion by fire: of this theory Dr. Hutton is the principal champion. That the surface of our globe was once in a fluid state, is established by very ample evidence. In the greater number of the strata of the earth, in the most elevated, as well as at the greatest depths, substances are found in a crystallized state; and even many of these strata have marks of crystallization in their entire structure. Crystallization is the arrangement of particles in a regular determinate form: and it necessarily implies a previous state of fluidity which would allow these particles to arrange themselves in positions necessary to produce these forms. Many of the more solid strata contain in their substance remains or impressions of animals and vegetables; and it is obvious that to admit of the introduction of such substances, they must at one time have been, if not in a perfectly fluid, at least in a soft or yielding state. In addition to this, the general disposition of the materials of the globe, so far as has been explored, must have arisen from fluidity, as this only could have arranged them in beds or strata, parallel to each other, and preserving that parallelism to a great extent. These appearances are not partial, but extend to the whole surface of the earth, and prove beyond a doubt its former fluidity. There are only two ways by which that fluidity can be supposed to have taken place; either the solid matter must have been fused by the action of heat, or it must have been dissolved in some fluid. These are the primary principles upon which the geological theories have been formed under different modifications. Of that which has heat for its foundation, we shall treat under the head of Vulcanic Theory. The other, which has been called the Neptunian Theory, is the subject of this article.—From the appearances which fossils present, it is inferred that they cannot have been

formed by fusion, and as solution in an aqueous fluid is the only other mode which presents itself, that would appear to be the efficient cause. Granite being the rock which composes the most elevated part of the globe, and which forms the basis upon which the greater number of the strata rest, is supposed to have been first formed; the different parts of which it consists, felspar, quartz, and mica, having concreted by a crystallization nearly simultaneous. A similar consolidation of the other primitive strata, gneiss, micaceous schistus, argillaceous schistus, porphyry, and quartz, is supposed to have taken place. In all these rocks there are never found any organic remains, and they must have been formed prior to the existence of the animal and vegetable kingdoms. From the period of the formation of these strata, it is supposed that the water began to diminish in height, by retiring into the crevices in the internal parts of the earth. During this period other precipitations, chemical and mechanical, continued to take place, and formed the intermediate strata of Werner, or the strata of transition; of which some varieties of limestone, schistus and trap are the principal. These are incumbent on the primary strata, and sometimes, but very rarely, contain petrifactions—a proof that the existence of marine animals had commenced with their formation. The diminution of the waters still continuing, and acting mechanically on the strata formed, caused a partial disintegration. The materials from this source, together with the remaining part of the matter originally dissolved by their precipitation and consolidation, formed what are called secondary strata, or the stratified rocks, sandstone, limestone, gypsum, puddingstone, some varieties of trap, and some others. These are of a height much less than the others. They are arranged generally in horizontal beds, and abound in organic remains; which is a proof of their formation, after the full developement of the animal and vegetable kingdoms. These three formations compose the whole substance of the surface of the globe, with merely the trivial addition of the products of volcanic fires, and the alluvial beds of sand, clay and soil arising from the waste of the strata from the waters which run over them. During the consolidation of these strata, rents happened in them, by which cavities of various dimensions were formed, into which the water, holding various matters in solution, gained access, and hence the formation of mineral veins. Such is the substance of the Neptunian theory, which may also be called, from its chief supporter, Wernerian. It may be observed generally of this theory, that it agrees with a great number of the phenomena presented in exploring the strata in the mountainous regions of our globes, and particularly in Saxony, where Werner, its great supporter, gave his celebrated mineralogical lectures; but there are also many facts which it requires some ingenuity at all to reconcile with it; and great controversy has arisen between its adherents and those geologists who imagine they find, in the supposition of a fusion by fire, a more consistent and satisfactory explanation. Those geologists who enter with zeal into the controversy, will be apt to dwell with most satisfaction on the objections which they are able to bring against the theory of their opponents, and will be ready to assume, that as only two modes of accounting for geological phenomena present themselves, if the opposite theory be destroyed, their own is necessarily established. But persons who take less interest in the dispute will not so readily admit the inference, and will be inclined to suspect that the formation of the various strata of our globe may have arisen in a manner and from causes unknown at present, and will deem it more reasonable to decline assenting fully to either theory, and wait patiently the result of more enlarged knowledge of the properties of the component parts and of the combinations of matter. In short, they will decline becoming partizans on either side.—To the Neptunian theory it may be objected, that the matter of which the strata of the globe consists, is insoluble in water; or if so, only to a very small degree. The simple earths, which are found in any considerable quantity in nature, as lime, alumina, silica, and magnesia, are very sparingly soluble in water; and the different

earthy fossils which they form by combination are apparently insoluble. Upon what ground then can water be considered as the agent which has given them fluidity? To affirm that water was ever capable of dissolving these substances, is therefore clearly to ascribe to it powers which it confessedly has not at present, and is therefore to introduce an hypothesis not only gratuitous, but which may be said to appear to be impossible. It is in vain for the Neptunist, in reply to this, to bring arguments which are equally strong against the theory of his opponents; and it is only with zealots that the destruction of the Vulcanic theory will necessarily procure assent to the Neptunian. He must, therefore, meet this objection fairly—remove it, if he can, or, as far as possible, weaken its force. It must be confessed that the objection is partially weakened by the consideration, that it is scarcely correct to estimate the solubility of bodies when supposed to have been in a very finely diffused state, by what is their solubility when aggregated into a mass. When bodies are reduced to a very fine powder, they may be acted upon by other bodies, which formerly produced no effect. Corundum stone, consisting chiefly of aluminous earth, is insoluble in acids until reduced to powder. Flint cannot be acted upon by alkalis, until reduced to a very fine mechanical division; and in general the power of all solvents is prodigiously increased by the body to be dissolved being reduced to very fine particles. That this principle bears in a certain degree on the present objection, will appear from the consideration, that although silica or flint, in all ordinary circumstances, in any experiment which we can make, appears insoluble in water; yet nature sometimes presents it dissolved in water to our view. Siliceous stalactites, although rare, are sometimes met with, and in some mineral waters silica is found dissolved, of which a well known instance is in the water of the fountain of Geyser, in the island of Iceland. A hundred cubic inches of this water were found by Klaproth to hold, in solution, nine grains of silica, and by Dr. Black, were found to hold 10·8 grains. The same is found to be the case in various fountains in the Azores. In these cases the natural solvent power of the water is much increased by its great heat. It is stated by the Neptunist, that there is no improbability in the supposition that the caloric originally given to our planet, may, before that order was established which now exists, have been locally accumulated at the surface, and thereby contributed much to the solvent power of the water. It is farther brought forward, that it is no good argument against the solvent power of water over the materials of the globe, to show that its power is weak, or nearly imperceptible over them, when taken separately. What it may have been when the various earths and metals were in union together, it is impossible to say, but it probably was greater than at present. Two substances, which in themselves are insoluble in an acid, may be rendered soluble by being united. When the alkaline solutions of silica and alumina are mixed together in equal proportions, a firm gelatinous mass results, which is soluble in acids, whether concentrated or diluted; nay, even in distilled vinegar. No one could have imagined that the addition of alumina could have rendered silica, which by itself is insoluble in acids, so readily soluble; yet such, by experiment, is found to be the case; and it appears to the Neptunist not to be requiring too much to be allowed to suppose, that the union of other substances with silica may have rendered it soluble in water. It is impossible to argue from a knowledge of the properties of three or more simple substances, taken one by one, what may be the properties of a compound into which they enter, in various proportions. Carbon, hydrogen, oxygen, nitrogen, and phosphorus, are the component parts of innumerable animal and vegetable substances, which possess properties perfectly distinct from these simple component parts, and which never could have been foreseen by any chemical knowledge of these substances; there are very few that human skill or art can imitate. What combinations may have been amongst the substances which now form the solid parts of our globe, and what properties they may have had when thus combined,

it is impossible for us to know; but it is no difficult matter to believe that they may have been very soluble in water; and we may infer, therefore, that there is nothing incredible in the Neptunian theory, which supposes, that the strata, or component parts of the earth were once in a state of watery solution, and have been gradually separated and precipitated, and thereby formed those arrangements of matter such as we see on the surface of our globe. The objection, therefore, arising from the present insolubility of the earths and metals, is at least greatly extenuated, if not completely obviated. In addition to the reasoning now stated, it may also be observed, that most of the substances which we now suppose simple, are very probably compound. Till very lately, soda, potass, lime, magnesia, and strontian, were supposed simple bodies, and they are now known to be compound; being in fact metallic oxides, and silica is very likely a similar compound body. That the metals are simple, is more than we can venture to assert, and we can only say that they have not as yet been decomposed into any more simple substances; but what may be the primary elementary particles of the earths and metals, it is utterly impossible at present to determine: but considering the immense progress of discovery within the last 100 years, and presuming that the same attention to explore nature will be continued, it is not unreasonable to expect that future years will unfold new truths equally wonderful, which will as much affect the theories which may be received. What the ultimate particles of different bodies may be found to be, and what their properties when in a simple state, we cannot at present foresee: and we are not justifiable in asserting that they are not soluble in water, and that therefore the Neptunian theory is untrue. Another objection against the Neptunian theory is derived from the position of the strata of the globe. Some stratified rocks are vertical in their position, some horizontal, or nearly so, and others inclined at different angles to the horizon. It is asserted, that if matter were deposited from a fluid, it would arrange itself in a horizontal bed; and whence then does it arise that we find the strata in vertical or highly inclined positions, yet preserving a parallelism over very extended and varied incurvations? To this objection the Neptunist answers, that the deposition of strata was not the deposition of matter which had previously been mechanically suspended, and had subsided by rest, which in that case must have formed horizontal beds; but the Neptunian theory supposes the matter to have been chemically dissolved, and to have separated and concreted by a species of crystallization. These crystalline deposits would be in large irregular masses, as granite, the rock of primary formation is; and the fluid still continuing to deposit matter by crystallization, this matter would crystallize on the sides of the masses already produced. In the same way, the metallic veins have been filled by matter finding access to the clefts of the strata, and crystallizing, on the sides on which they would form an incrustation, and different kinds of matter finding access, different kinds of crystallization have taken place. Objections have been made to the Neptunian theory from the appearance of various minerals, which, it is argued by Plutonists or Vulcanists, could not have formed by deposits from watery solutions, and which bear the marks of having been produced by fire. To these objections answers are given more or less satisfactory. Upon the whole, it may safely be asserted, that to place faith on this, or any other theory, requires a great effort of imagination, and a supposition of circumstances and causes, of which we can have no adequate proof. Contemplations of this description open to our view grand and sublime views of the operations of nature on the chaotic mass of which our world has been formed. The controversy has led to the accurate exploring of nature in the mountainous regions, where her sublimity and grandeur are more particularly manifested; and has accordingly much increased the boundary of human knowledge. Many things may be admitted as true, others as probable; but many difficulties still remain, which in the present state of science it is impossible to solve.—See *Vulcanic Theory.*

NERIUM TINCTORUM, a tree growing in Hindostan, which will afford indigo.

NEUTRALIZATION. When acids and alkalies are combined so as to effect a change in each other's properties, they are said to be neutralized.

NICKEL, is a metal of great hardness, of a uniform texture, and of a colour between silver and tin; very difficult to be purified, and magnetical. It even acquires polarity by the touch. It is malleable, both cold and red-hot, and is scarcely more fusible than manganese. Its oxides, when pure, are reducible by a sufficient heat without combustible matter, and it is little more tarnished by heating in contact with air, than platina, gold, and silver. Its specific gravity when cast is 8·279; when forged, 8·666. Nickel is commonly obtained from its sulphuret, the kufernickel of the Germans, in which it is generally mixed also with arsenic, iron, and cobalt. This is first roasted, to drive off the sulphur and arsenic, then mixed with two parts of black flux, put into a crucible, covered with muriate of soda, and heated in a forge furnace. The metal thus obtained, which is still very impure, must be dissolved in dilute nitric acid, and then evaporated to dryness; and after this process has been repeated three or four times, the residuum must be dissolved in a solution of ammonia, perfectly free from carbonic acid. Being again evaporated to dryness, it is now to be well mixed with two or three parts of black flux, and exposed to a violent heat in a crucible for half an hour or more. According to Richter, the *oxide* is more easily reduced by moistening with a little oil. Thenard advises to pour chloride of *lime on* the oxide of nickel, and shake them well together before the ammonia is added; as thus the oxides of cobalt and iron, if present, will be so much saturated with oxygen, as to be insoluble in the ammonia, and consequently may be separated. M. Chenevix observed, that a very small portion of arsenic prevents nickel from being effected by the magnet. Richter found the same. When it is not attractible, therefore, we may be pretty certain that this is present. To separate the arsenic, M. Chenevix boiled the compound in nitric acid till the nickel was converted into an arseniate; decomposed this by nitrate of lead, and evaporated the liquor, not quite to dryness. He then poured in alcohol, which dissolved only the nitrate of nickel. The alcohol being decanted and evaporated, he re-dissolved the nitrate in water, and precipitated by potash. The precipitate, well washed and dried, he reduced in a Hessian crucible lined with lamp black, and found it to be perfectly magnetic; but this property was destroyed again by alloying the metal with a small portion of arsenic. Alloying it with copper weakens this property. The sulphuric and muriatic acids have little action upon nickel. The nitric and nitro-muriatic are its most appropriate solvents. The nitric solution is of a fine grass-green colour. Carbonate of potash throws down from it a pale apple-green precipitate, which, when well washed and dried, is very light. One part of metal gives 2·927 of this precipitate, which by exposure to a white heat becomes blackish-grey, barely inclining to green, and weighing only 1·285. By continuing the fire it is reduced. When ammonia is added in excess to a nitric solution of nickel, a blue precipitate is formed, which changes to a purple-red in a few hours, and is converted to an apple-green by an aci . If the precipitate retain its blue colour, copper is present. There are two oxides of nickel the black and the grey

NICOTIN, a peculiar principle in tobacco. It is colourless, volatile, and poisonous, with the peculiar taste of the plant.

NIGRINE, an ore of Titanium.

NIHIL ALBUM, a name formerly given to the flowers, or white oxide of zinc.

NITRATES, compounds of nitric acid with the salifiable bases.

NITRE, the common name of the nitrate of potash. It is known by the name of saltpetre, and is found ready formed in the East Indies, in Spain, in the kingdom of Naples, and elsewhere, in considerable quantities, but nitrate of lime is still more abundant. Far the greater part of the nitrate made use of, is produced by a combination of circumstances which tend to compose and condense

nitric acid. This acid appears to be produced in all situations where animal matters are completely decomposed with access of air, and of proper substances with which it can readily combine. Grounds frequently trodden by cattle and impregnated with their excrements, or the walls of inhabited places where putrid animal vapours abound, such as slaughter-houses, drains, or the like, afford nitre by long exposure to the air. Artificial nitre beds are made by an attention to the circumstances in which this salt is produced by nature. Dry ditches are dug, and covered with sheds, open at the sides, to keep off the rain: these are filled with animal substances, such as dung, or other excrements, with the remains of vegetables, and old mortar, or other loose calcareous earth; this substance being found to be the best and most convenient receptacle for the acid to combine with. Occasional watering, and turning up from time to time, are necessary, to accelerate the process and increase the surfaces to which the air may apply; but too much moisture is hurtful. When a certain portion of nitrate is formed, the process appears to go on more quickly: but a certain quantity stops it altogether, and after this cessation the materials will go on to furnish more, if what is formed be extracted by lixiviation. After a succession of many months, more or less, according to the management of the operation, in which the action of a regular current of fresh air is of the greatest importance, nitre is found in the mass. If the beds contained much vegetable matter, a considerable portion of the nitrous salt will be common saltpetre; but if otherwise, the acid will, for the most part, be combined with the calcareous earth. It consists of 6·75 acid + 5·95 potash. To extract the saltpetre from the mass of earthy matter, a number of large casks are prepared, with a cock at the bottom of each, and a quantity of straw within, to prevent its being stopped up. Into these the matter is put, together with wood-ashes, either strewed at top, or added during the filling. Boiling water is then poured on, and suffered to stand for some time; after which it is drawn off, and other water added in the same manner, as long as any saline matter can be thus extracted. The weak brine is heated, and passed through other tubs, until it becomes of considerable strength. It is then carried to the boiler, and contains nitre and other salts, the chief of which is common culinary salt, and sometimes muriate of magnesia. It *is the property of nitre to be much* more soluble in hot than cold water; but common salt is very nearly as soluble in cold as in hot water. Whenever, therefore, the evaporation is carried by boiling to a certain point, much of the common salt will fall to the bottom, for want of water to hold it in solution, though the nitre will remain suspended by virtue of the heat. The common salt thus separated is taken out with a perforated ladle, and a small quantity of the fluid is cooled from time to time, that its concentration may be known by the nitre which crystallizes in it. When the fluid is sufficiently evaporated, it is taken out and cooled, and great part of the nitre separates in crystals, while the remaining common salt continues dissolved, because equally soluble in cold and hot water. Subsequent evaporation of the residue will separate more nitre in the same manner. By the suggestion of Lavoisier, a much simpler plan was adopted,—reducing the crude nitre to powder, and washing it twice with water. This nitre, which is called nitre of the first boiling, contains some common salt, from which it may be purified by solution in a small quantity of water, and subsequent evaporation; for the crystals thus obtained are much less contaminated with common salt than before, because the proportion of water is so much larger, with respect to the small quantity contained by the nitre, that very little of it will crystallize. For nice purposes, the solution and crystallization of nitre are repeated four times. The crystals of nitre are usually of the form of six-sided flattened prisms, with diedral summits. Its taste is penetrating; but the cold produced by placing the salt to dissolve in the mouth is such as to predominate over the real taste at first. Seven parts of water dissolve two of nitre, at the temperature of sixty degrees; but boiling water dissolves its

own weight. One hundred parts of alcohol, at a heat of 176 degrees, dissolve only 2·9. On being exposed to a gentle heat, nitre fuses; and in this state being poured into moulds, so as to form little round cakes, or balls, it is called *sal prunella*, or *crystal mineral*. This at least is the way in which this salt is now usually prepared, conformably to the directions of Boerhaave, though in most dispensatories a twenty-fourth part of sulphur was directed to be deflagrated on the nitre before it was poured out. This salt should not be left on the fire after it has entered into fusion, otherwise it will be converted into a nitrate of potash. If the heat be increased to redness, the acid itself is decomposed, and a considerable quantity of tolerably pure oxygen gas is evolved, succeeded by nitrogen. This salt powerfully promotes the combustion of inflammable substances. Two or three parts mixed with one of charcoal, and set on fire, burn rapidly; azote and carbonic acid gas are given out and a small portion of the latter is retained by the alkaline residuum, which was formerly called clyssus of nitre. Three parts of nitre, two of subcarbonate of potash, and one of sulphur, mixed together in a warm mortar, form the fulminating powder; a small quantity of which, laid on a fire-shovel, and held over the fire till it begins to melt, explodes with a loud sharp noise. Mixed with sulphur and charcoal, it forms gunpowder.—See *Gunpowder*. Three parts of nitre, one of sulphur, and one of fine saw-dust well mixed, constitute what is called the powder of fusion. If a bit of base copper be folded up and covered with this powder in a walnut shell, and the powder be set on fire with a lighted paper, it will detonate rapidly, and fuse the metal into a globule of sulphuret, without burning the shell. If nitrate of potash be heated in a retort, with half its weight of solid phosphoric or boracic acid, as soon as this acid begins to enter into fusion, it combines with the potash, and the nitric acid is expelled, accompanied with a small portion of oxygen gas and nitric oxide. Silex, alumina, and barytes, decompose this salt in a high temperature, by uniting with its base. The alumina will effect this even after it has been made into pottery. The uses of nitre are various. Beside those already indicated, it enters into the composition of fluxes, and is extensively employed in metallurgy; it serves to promote the combustion of sulphur in fabricating its acid; it is used in the art of dying; it is added to common salt for preserving meat, to which it gives a red hue; it is an ingredient in some frigorific mixtures, and it is prescribed in medicine as cooling, febrifuge, and diuretic; and some have recommended it mixed with vinegar, as a very powerful remedy for the sea scurvy.

NITRIC ACID. The two principal constituent parts of our atmosphere, when in certain proportions, are capable, under particular circumstances, of combining chemically into one of the most powerful acids—the nitric. If these gases be mixed in a proper proportion in a glass tube about a line in diameter, over mercury, and a series of electric shocks be passed through them for some hours, they will form nitric acid; or if a solution of potash be present with them, nitrate of potash will be obtained. The constitution of this acid may be further proved, analytically, by driving it through a red-hot porcelain tube, as thus it will be decomposed into oxygen and nitrogen gases. For all practical purposes, however, the nitric acid is obtained from nitrate of potash, from which it is expelled by sulphuric acid. Three parts of pure nitrate of potash, coarsely powdered, are to be put into a glass retort, with two of strong sulphuric acid. This must be cautiously added, taking care to avoid the fumes that arise. Join to the retort a tubulated receiver of large capacity, with an adopter interposed, and lute the junctures with glazier's putty. In the tubulure fix a glass tube, terminating in another large receiver, in which is a small quantity of water; and if you wish to collect the gaseous products, let a bent glass tube from this receiver communicate with a pneumatic trough. Apply heat to the receiver by means of a sand-bath. The first product that passes into the receiver is generally red and fuming, but the appearances gradually diminish, till the acid comes over pale, and even colourless, if the materials used were

clean. After this it again becomes more and more red and fuming, till the end of the operation; and the whole mingled together will be of a yellow or orange colour. In the large way, and for the purposes of the arts, extremely thick cast iron or earthen retorts are employed, to which an earthen head is adapted, and connected with a range of proper condensers. The strength of the acid too is varied, by putting more or less water in the receivers. The nitric acid thus made generally contains sulphuric acid, and also muriatic, from the impurity of the nitrate employed. If the former, a solution of nitrate of barytes will occasion a white precipitate; if the latter, nitrate of silver will render it milky. The sulphuric acid may be separated by a second distillation from very pure nitre, equal in weight to an eighth of that originally employed; or by precipitating with nitrate of barytes, decanting the clear liquid, and distilling it. The muriatic acid may be separated by proceeding in the same way with nitrate of silver, or with litharge, decanting the clear liquor, and re-distilling it, leaving an eighth or tenth part in the retort. The acid for the last process should be condensed as much as possible, and the re-distillation conducted very slowly: and if it be stopped when half is come over, beautiful crystals of muriate of lead will be obtained on cooling the remainder, if litharge be used, as M. Steinacher informs us; who also adds, that the vessels should be made to fit tight, by grinding, as any lute is liable to contaminate the product. As this acid still holds in solution more or less nitrous gas, it is not in fact nitric acid, but a kind of nitrous; it is therefore necessary to put it into a retort, to which a receiver is added, the two vessels not being luted, and to apply a very gentle heat for several hours, changing the receiver as soon as it is filled with red vapours. The nitrous gas will thus be expelled, and the nitric acid will remain in the retort as limpid and colourless as water. It should be kept in a bottle secluded from the light, otherwise it will lose part of its oxygen. What remains in the retort is a bisulphate of potash, from which the superfluous acid may be expelled by a pretty strong heat, and the residuum being dissolved and crystallized, will be sulphate of potash. As nitric acid in a fluid state is always mixed with water, different attempts have been made to ascertain its strength, or the quantity of real acid contained in it. Mr. Kirwan supposed, that the nitrate of soda contained the pure acid undiluted with water, and thus calculated its strength from the quantity requisite to saturate a given portion of soda. Sir H. Davy more recently took the acid in the form of gas as the standard, and found how much of this is contained in an acid of a given specific gravity in the liquid state. The nitric acid is of considerable use in the arts. It is employed for etching on copper; as a solvent of tin to form with that metal a mordant for some of the finest dyes; in metallurgy and assaying; in various chemical processes, on account of the facility with which it parts with oxygen and dissolves metals; in medicine as a tonic, and as a substitute for mercurial preparations in syphilis and affections of the liver; as also in form of vapour, to destroy contagion. For the purposes of the arts it is commonly used in a diluted state, and contaminated with the sulphuric and muriatic acids, by the name of aquafortis. This is generally prepared by mixing common nitre with an equal weight of sulphate of iron, and half its weight of the same sulphate calcined, and distilling the mixture; or by mixing nitre with twice its weight of dry powdered clay, and distilling in a reverberatory furnace. Two kinds are found in the shops, one called double aquafortis, which is about half the strength of nitric acid, the other simply aquafortis, which is half the strength of the double. A compound made by mixing two parts of the nitric acid with one of muriatic, known formerly by the name of aqua regia, and now by that of nitro-muriatic acid, has the property of dissolving gold and platina. On mixing the two acids heat is given out, an effervescence takes place, and the mixture acquires an orange colour. This is likewise made by adding gradually to an ounce of powdered muriate of ammonia, four ounces of double aquafortis, and keeping the mixture in a sand-heat till the salt is dissolved, taking care to avoid the fumes, as the

vessel must be left open; or by distilling nitric acid with an equal weight, or rather more, of common salt. The aqua regia does not oxydize gold and platinum, but merely causes their combination with chlorine. The nitrate of barytes, when perfectly pure, is in regular octaëdral crystals, though it is sometimes obtained in small shining scales. It may be prepared by uniting barytes directly with nitric acid, or by decomposing the carbonate or sulphuret of barytes with this acid. Exposed to heat it decrepitates, and at length gives out its acid, which is decomposed; but if the heat be urged too far, the barytes is apt to vitrify with the earth of the crucible. It is soluble in 12 parts of cold, and 3 or 4 of boiling water. It is said to exist in some mineral waters. It consists of 6·75 acid + 9·75, or 9·7 base. Nitrate of strontian may be obtained in the same manner as that of barytes, with which it agrees in the shape of its crystals, and most of its properties. It is much more soluble, however, requiring but four or five parts of water according to Vauquelin, and only an equal weight according to Mr. Henry. Boiling water dissolves nearly twice as much as cold. Applied to the wick of a candle, or added to burning alcohol, it gives a deep red colour to the flame. On this account it may be useful, perhaps, in the art of pyrotechny. Nitrate of lime, the calcareous nitre of older writers, abounds in the mortar of old buildings, particularly those that have been much exposed to animal effluvia, or processes in which azote is set free. Hence it abounds in nitre beds, as was observed when treating of the nitrate of potash. It may also be prepared artificially, by pouring dilute nitric acid on carbonate of lime. If the solution be boiled down to a syrupy consistence, and exposed in a cool place, it crystallizes in long prisms, resembling bundles of needles diverging from a centre. These are soluble, according to Henry, in an equal weight of boiling water, and twice their weight of cold; soon deliquesce on exposure to the air, and are decomposed at a red heat. Fourcroy says, that cold water dissolves four times its weight, and that its own water of crystallization is sufficient to dissolve it at a boiling heat. It is likewise soluble in less than its weight of alcohol. By evaporating the aqueous solution to dryness, continuing the heat till the nitrate fuses, keeping it in this state five or ten minutes, and then pouring it into an iron pot previously heated, we obtain Baldwin's phosphorus. This, which is perhaps more properly nitrate of lime, being broken to pieces, and kept in a phial closely stopped, will emit a beautiful white light in the dark, after having been exposed some time to the rays of the sun. At present, no use is made of this salt, except for drying some of the gases by attracting their moisture; but it might be employed instead of the nitrate of potash for manufacturing aquafortis. The nitrate of ammonia possesses the property of exploding, and being totally decomposed, at the temperature of 600 deg.; whence it acquired the name of nitrum flammans. The readiest mode of preparing it is by adding carbonate of ammonia to dilute nitric acid till saturation takes place. If this solution be evaporated in a heat between 70 deg. and 100 deg., and the evaporation not carried too far, it crystallizes in hexaedral prisms terminating in very acute pyramids: if the heat rise to 212 deg., it will afford, on cooling, long fibrous silky crystals: if the evaporation be carried so far as for the salt to concrete immediately on a glass rod by cooling, it will form a compact mass. According to Sir H. Davy, these differ but little from each other, except in the water they contain, their component parts being as follows:—

	contains of acid	ammonia	water
Prismatic,	69·5	18·4	12·1
Fibrous,	72·5	19·3	8·2
Compact,	74·5	19·8	5·7

All these are completely deliquescent but they differ a little in solubility. Alcohol at 176 deg. dissolves nearly 90·9 of its own weight. When dried as much as possible without decomposition, it consists of 67·6 acid + 21·3 ammonia, 11·5 water. The chief use of this salt is for affording nitrous oxide on being decomposed by heat. Nitrate of magnesia, magnesian nitre, crystallizes in four-sided rhomboidal prisms, with oblique or truncated summits, and sometimes in bundles of

small needles. Its taste is bitter, and very similar to that of nitrate of lime, but less pungent. It is fusible, and decomposable by heat, giving out first a little oxygen gas, then nitrous oxide, and lastly, nitric acid. It deliquesces slowly. It is soluble in an equal weight of cold water, and in but little more hot, so that it is scarcely crystallizable but by spontaneous evaporation. The two preceding species are capable of combining into a triple salt, an ammoniaco-magnesian nitrate, either by uniting the two in solution, or by a partial decomposition of either by means of the base of the other. This is slightly inflammable when suddenly heated; and by a lower heat is decomposed, giving out oxygen, azote, more water than it contained, nitrous oxide and nitric acid. The residuum is pure magnesia. It is disposed to attract moisture from the air, but is much less deliquescent than either of the salts that compose it, and requires 11 parts of water at 60 deg. to dissolve it. Boiling water takes up more, so that it will crystalize by cooling. It consists of 78 parts of nitrate of magnesia, and 22 of nitrate of ammonia. From the activity of the nitric acid as a solvent of earths in analyzation, the nitrate of glucine is better known than any other of the salts of this new earth. Its form is either pulverulent, or a tenacious or ductile mass. Its taste is at first saccharine, and afterward astringent. It grows soft by exposure to heat, soon melts, its acid is decomposed into oxygen and azote, and its base alone is left behind. It is very soluble and very deliquescent. Nitrate, or rather super-nitrate, of alumina crystallizes, though with difficulty, in thin, soft, pliable flakes. It is of an austere and acid taste, and reddens blue vegetable colours. It may be formed by dissolving in diluted nitric acid, with the assistance of heat, fresh precipitated alumina, well washed but not dried. It is deliquescent, and soluble in a very small portion of water. Alcohol dissolves its own weight. It is easily decomposed by heat. Nitrate of zircone was first discovered by Klaproth, and has since been examined by Guyton-Morveau and Vauquelin. Its crystals are small, capillary, silky needles. Its taste is astringent. It is easily decomposed by fire, very soluble in water, and deliquescent. It may be prepared by dissolving zircone in strong nitric acid; but, like the preceding species, the acid is always in excess. Nitrate of yttra may be prepared in a similar manner. Its taste is sweetish and astringent. It is scarcely to be obtained in crystals; and if it be evaporated by too strong a heat, the salt becomes soft like honey, and on cooling, concretes into a stony mass.

NITRIC ACID OXYGENIZED. If the peroxide of barium obtained by saturating barytes with oxygen, be moistened, it will fall to powder. Dissolve this powder in seven or eight times its weight, by dilute nitrous acid poured gradually upon it, the solution will be neutral and will have no action on turnsole or turmeric. If to this solution sulphuric acid be added, the sulphate of barytes is precipitated and the liquid is merely water holding in solution oxygenized nitric acid, which is colourless, and resembles in all its properties, nitric acid. By being heated, it will give out its superabundant oxygen. If a tube containing oxide of silver, be plunged into a solution of oxygenized nitrate of potash, the oxygen will be discharged both from the silver and solution: pure silver will be the result, and the liquor will be merely a solution of nitrate of potash. If silver in filings be put into a solution of oxygenized nitrate of potass or muriate of potass, the oxygen is disengaged and the silver remains unattacked. Copper, bismuth, lead, and platinum filings have the same effect and are not oxidized: iron and zinc are oxidized. This acid dissolves the peroxides of lead and manganese, which nitric acid will not. These peroxides will decompose oxynitrates of iron and zinc.

NITROGEN, also called azote, is substance which exists in great abundance, but is never found but in combination with some other body. It is a principal component part of the air which we breathe, which consists of 78 parts of nitrogen, and 22 of oxygen. It is accordingly here united with oxygen, and a certain portion of caloric and light. There are various other combinations of nitrogen and other bodies, of which we

shall hereafter attempt to give an account. The nitrogen and oxygen of the atmospheric air may be separated, so that we may have the nitrogen by itself, but then only in a state of gas, and its properties are very different from those of the atmospheric air. The most convenient process for obtaining nitrogen gas, is to place in a large basin of water a smaller basin, containing equal parts of sulphur and iron filings, made into a paste; and placing a large glass vessel or glass bell, with the mouth downwards, over this small basin in the water. The paste will soon absorb the oxygen enclosed in the glass vessel, and in proportion as it does so, the pressure of the external air will cause the water to rise until the oxygen being exhausted, about three-fourths of the vessel will be left filled with nitrogen. Nitrogen gas will not support animal life. If a mouse or bird were introduced into a nitrogen gas, obtained in the manner pointed out, death would instantly ensue. If a bird or mouse were introduced under a glass vessel placed with the mouth downward, as already pointed out, gradually as the oxygen was consumed the water would rise, and the animal would soon pant hard, and if not relieved, would die. Nitrogen gas will not support combustion. It is an inviolable rule in nature, that where animal life will not be supported, neither will combustion, and vice versâ. A taper introduced into a vessel containing nitrogen gas will instantly be extinguished. If a taper be introduced under a glass vessel, as in the preceding experiment, it will soon exhaust great part of the oxygen enclosed, and will burn feeble and then go out. Nitrogen gas is a little heavier than atmospheric air, it is elastic and capable of expansion and condensation. It produces no change on vegetable colours, and when mixed with lime water does not make it milky, as is the case with carbonic acid gas. Nitrogen gas and oxygen gas artificially mixed together in proportions in which air is found in the atmosphere, have exactly the same properties as atmospheric air, which in every respect in fact they become. All animal and vegetable substances contain a large portion of nitrogen. Different proportions of oxygen united with nitrogen produce compounds of very different properties. We have seen that 78 parts of nitrogen and 22 of oxygen, produce atmospheric air. The same quantity of nitrogen with twice as much of oxygen make 100 of nitrous oxide. The same quantity of nitrogen and four times as much oxygen make nitric oxide. The same quantity still of nitrogen, and eight times the quantity of oxygen, make nitrous acid. The same quantity of nitrogen, and ten times the quantity of oxygen, make nitric acid. Thus, the only difference between atmospheric air, so necessary to life, and nitric acid, which would corrode and destroy us if received internally, consists in this, that the latter contains ten times as much of oxygen as the former. Nitrous oxide is a gas which is chiefly remarkable for its intoxicating effects, when inhaled, and at public lectures it affords much amusement to the spectators. It is obtained by distilling the salt called nitrate of ammonia. Nitrous oxide and nitrous acid are not of much importance. Nitric acid we have noticed already. Nitrogen combines with chlorine. This substance is dangerously explosive, and must be carefully and cautiously heated. It unites also with iodine.

NITROUS ACID. It was formerly called fuming nitrous acid. It appears to form a distinct genus of salts that may be termed nitrites. But these cannot be made by a direct union of their component parts, being obtainable only by exposing a nitrate to a high temperature, which expels a portion of its oxygen in the state of gas, and leaves the remainder in the state of a nitrite, if the heat be not urged so far, or continued so long, as to effect a complete decomposition of the salt. In this way the nitrites of potash and soda may be obtained, and, perhaps, those of barytes, strontian, lime, and magnesia. The nitrites are particularly characterized, by being decomposable by all the acids, except the carbonic, even by the nitric acid itself, all of which expel from it nitrous acid. We are little acquainted with any one, except that of potash, which attracts moisture from the air, changes blue vegetable colours to green, is some-

what acrid to the taste, and when powdered, emits a smell of nitric oxide.

NOBLE METALS. This name has been given to gold, silver, and platinum.

NOMENCLATURE. The chemists of former times were unfortunate in the nomenclature which they adopted, there being no regular system, and the names given to chemical substances being frequently fanciful, and often leading to error. In addition to this, chemists affected obscurity and mystery; and hence the whole chemical no- [illegible] h [illegible] rogeneous mass of fancy and absurdity, and improper in the present state of science. In addition to this, the number of substances and of their compounds is now so great, that were a distinct and unconnected name to be given to each, no human memory could possibly recollect them. To obviate these inconveniences, Lavoisier and the French chemists proposed, and successfully introduced, a chemical nomenclature, of which the basis is simplicity, and which is intended, as far as possible, to convey an idea of the composition of the substance expressed. Thus, instead of the names, Glauber's Salt, or Wonderful Salt, the present nomenclature is sulphate of soda, by which is at once stated, that it is the neutral salt composed of the sulphuric acid and soda; instead of Epsom Salt, Salt of Canal, Salt of Seidlitz, or Bitter Cathartic Salt, Salt of Egra, and various others, which convey no meaning, the present nomenclature substitutes Sulphate of Magnesia, the salt being composed of the sulphuric acid and magnesia. Thus it is throughout the whole of the present nomenclature; the object is to reject all obscure, fanciful terms, and at once use an expression which will convey as nearly as possible the nature of the substance in question. Where a substance is simple, without any other substance combined with it, one simple name is given. Thus, the metals have each their distinguishing name, as gold, silver, iron, &c.; and the alchemical terms of sun, moon, mars, &c. are rigorously rejected, as are the terms derived from them,—solar, lunar, martial, &c. If oxygen be combined, as in the iron, for example, the expression is oxide of iron, or of whatever metal it may be. If a salt has been formed by the solution of a metal in an acid, an expression is used which conveys the composition. Thus, sulphate of iron, for the salt formed by the solution of iron in sulphuric acid; nitrate of iron, for the salt formed from the solution of iron in nitric acid. Oxygen being one of the most important substances in chemistry, and the greatest changes being occasioned by its combinations, these have been indicated by suitable chemical expressions. Thus, a com- [illegible] d any metal, called an oxide of that metal,—as oxide of iron, oxide of tin, &c.; so also its combination with any other substances, as oxide of carbon, oxide of sulphur. But as oxygen unites in different proportions, distinguishing expressions have been employed. Thus, where the first or lowest quantity of oxygen united, any particular substance is called its protoxide; the next combination is called the deutoxide, the third the tritoxide, and where there are several oxides, that which has the greatest quantity, whether second, third, or fourth, is called the peroxide. A combination of carbon with any substance, is called the carburet of that substance,—as carburet of iron. Where there is a double portion of carbon, it is called the bicarburet, and substances containing carbon may be said to be carburetted,—as carburetted hydrogen gas; and where there is a double quantity, bicarburetted hydrogen gas. A similar phraseology is used to express the combination of other substances,—as the phosphuret, bi-phosphuret, sulphuret, bi-sulphuret. The combinations of iodine are called iodides. To express the relative quantities of oxygen in the different acids, a slight alteration of the termination suffices. Thus, sulphuric acid, and sulphurous acid; nitric acid, and nitrous acid, &c.; where the termination in *ic* shews that which has the larger quantity of oxygen. To make still greater distinction, the Latin prepositions, *super*, above, and *sub*, under, will indicate a greater or less degree; and the Greek prepositions *hyper*, above, and *hypo*, under, are employed in a similar way. The same distinctions are made in the salts formed from the

union of the acids with the oxides of the metals and the earths. Thus, sulphate of iron is the salt formed from sulphuric acid and the oxide of iron; sulphate of iron is the salt formed from the sulphurous acid and the oxide of iron. We have carbonates, supercarbonates, subcarbonates, and so on. There is an inconvenience in this system of nomenclature, when it is affectedly made use of by chemists, when attempting to write or speak in a popular manner, when treating of substances which are in common use, and familiarly known to every body by their ordinary names. This has much the same effect as the mysterious language of the alchemists of former ages, and should be avoided. A more important objection is, that in many cases chemists have been mistaken in their opinions of the component parts of bodies, and have given them names which on farther examination they have been obliged to alter. As, however, science becomes more perfect, such a circumstance will more rarely occur.

NOVACULITE. Whetstate.

NUTRIMENT in different kinds of grain.—See *Grain*.

NUX VOMICA.—See *Strychnia*.

O.

OAK BARK. One thousand parts of dry oak bark, from a small tree deprived of epidermis, contain,

Of woody fibre	876
— tannin	67
— extract	31
— mucilage	18
— matter rendered insoluble during evaporation, probably a mixture of albumen and extract	9
— loss, partly saline matter	30

OBSIDIAN, a volcanic glass so nearly resembles lumps of black glass, that it is not easily to be distinguished. Its surface is smooth, it is hard, and strikes fire with steel. It is common in the neighbourhood of volcanoes, and in some basalts, which are probably the products of volcanic fires now extinguished. In Lipari, one of the volcanic isles, the mountain de la Castagna, according to Spalanzani, is wholly composed of volcanic glass, which appears to have flowed in successive currents, like streams of water falling with a rapid descent, and suddenly frozen. This glass is sometimes compact, and sometimes porous and spungy. Obsidian appears to be lava suddenly cooled; if a mass of lava or basalt be exposed to the heat of a glass furnace, it melts into a shining black or greenish black glass. Numerous veins of obsidian are said to intersect the cone of Mount Vesuvius, and serve as a cement to keep together the loose materials of which it is composed. Obsidian is sometimes ground and polished, and used for mirrors. There are two kinds, the translucent and transparent. 1. Translucent obsidian.—Colour, velvet black; transiucent, or translucent on the edges; hard; very brittle; spec. grav. 2·37 It melts or becomes spongy before the blow-pipe; its constituents are silica 78, alumina 10, lime 1, soda 1·6, potash 6, oxide of iron 1. 2. Transparent.—Colour, duck-blue; massive, and in brown grains; transparent; spec. grav. 2·36. It melts more easily than the translucent obsidian. Its constituents are silica 81, alumina 9·5, lime 0·33, oxide of iron 0·60, potash 2·7, soda 4·5, water 0·5.

OCHRE. An ore of iron.

OCHROITS. Cerite.

OETITES. Clay-ironstone.

OIL OF VITRIOL. A name vulgarly given to sulphuric acid.

OIL. The distinctive characters of oil are inflammability, insolubility in water, and fluidity, at least in a moderate temperature. Oils are distinguished into fixed or fat oils, which do not rise in distillation at the temperature of boiling water, and volatile or essential oils, which do rise at that temperature with water, or under 320 deg. by themselves. The volatile oil obtained by attenuating animal oil, by a number of successive distillations, is called Dippel's animal oil. Mounet asserts, that by mixing acids with animal oil, their rectification may be very much facilitated. The addition of a little ether, before redistillation of old essential oils, improves the flavour of the product.

OIL GAS. If oil, tallow, or wax be let fall upon red-hot iron, or made to pass through red-hot iron pipes, it will be resolved into a combustible

gas. This fact was long known to chemists; and after the success of lighting by coal-gas was made apparent, Messrs Taylor and Martineau contrived an ingenious apparatus for producing oil gas on a large scale, as a substitute for candles, lamps, and coal gas. Oil gas has several advantages over coal gas. It has no unpleasant smell in a room; it does not require the expense of being purified by lime; it will not injure in the least books, pictures, or fine furniture; it has no corrosive effect on the pipes which convey it. It is far more economical than argand lamps, mould, or wax candles. It gives a very bright light; and one cubic foot of oil gas will yield much more light than the same quantity of coal gas. This last is a great advantage, where saving of room is important. In the course of their experiments, Messrs. Taylor discovered that their iron retorts gradually were diminished in their power of producing gas, and that however much they might be cleaned, their original power was not restored; to obviate this, they introduced fragments of brick, and were so fortunate as to find, that a great increase of the decomposing power was thereby obtained; so that the apparatus was much improved by what at first appeared to threaten their success. A small portion of the oil introduced into the retort still passed off undecomposed, and being changed into a volatile oil, carried off part of the caloric; but this difficulty has been obviated by contriving to make this volatile oil return into the oil reservoir, from which it again passes into the retort. This reservoir is so arranged, that the oil may flow into the retorts in such proportions as to regulate the production of gas at a moderate rate.

OISANITE. Pyramidal Titanium ore.

OLEFIANT GAS. This gas differs from the common gas in this, that it consists of one prime of carbon, and one of hydrogen, instead of one prime of carbon and two of hydrogen.

OLEIC ACID, is an oil obtained from potass and hogs' lard saponified, which has the property of saturating bases and forming neutral compounds. It may be made from any other fat. 100 of that from hog fat will saturate 27 of barytes, 20·38 of strontian, and 81·80 of lead. The oleic acid from human fat, sheep fat, ox fat, and goose, will saturate very nearly the same amount.

OLEOSACCHARUM. This name is given to a mixture of oil and sugar, incorporated with each other, to render the oil more easily diffusible in watery liquors.

OLEUM VINI. See *Ether*.

OLIBANUM. A gum resin, the product of the Juniperus Lycia, brought from Turkey and the East Indies, usually in drops or tears. The best is of a yellowish-white colour, solid, hard, and brittle: when chewed for a little time, it renders the spittle white, and impresses an unpleasant bitterish taste; laid on burning coals, it yields an agreeable smell.

OLIVENITE. An ore of copper.

OLIVINE, a sub-species of prismatic chrysolite. It consists of 50 silica, 38.5 magnesia, 0·25 lime, oxide of iron 12.

OLLARIS LAPIS, or potstone. It is found abundantly near the lake of Como, and is made into pots. It is also employed in Greenland. Its constituents are silica 39, magnesia 16, oxide of iron 10, carbonic acid 20, water 10. It occurs in beds of primitive slate.

OMPHACITE, a mineral of a leek green colour, found in Carinthia.

ONYX. A calcedony with alternate layers of white, black, and dark brown.

OPACITY. The property of obstructing the rays of light.

OPAL. A sub-species of the indivisible quartz of Mohs. Of opal there are seven kinds.

1. Precious opal. Colour, milk-white, inclining to blue. It exhibits a beautiful play of many colours. Before the blow-pipe it whitens and becomes opaque, but does not fuse. Its constituents are, silica 90, water 10. Some of them become transparent by immersion in water; and are called oculus mundi, hydrophane, or changeable opal.

2. Common opal. Colour, milk-white. Infusible. Its constituents are, silica 93·5, oxide of iron 1, water 5.

3. Fire opal. Colour, hyacinth-red. Heat changes the colour to pale flesh-red. Its constituents are, silica 92 water 7·75, iron 0·25.

4. Mother-of-pearl opal, or Cacholong. It is a variety of calcedony.

5. Semi-opal. Colours, white, grey, and brown, sometimes in spotted, striped, or clouded delineations. Its constituents are, silica 85, alumina 3, oxide of iron 1·75, carbon 5, ammoniacal water 8, bituminous oil 0·33.

6. Jasper opal, or ferruginous opal. Colour, scarlet-red, and grey. Its constituents are, silica 43·5, oxide of iron 47·0, water 7·5.

7. Wood opal. Colours very various. In branched pieces and stems.

OPIUM is obtained from poppy seeds. It is procured from Turkey, and is also now produced to a large amount in India, and is exported to China. It is a powerful narcotic. See *Morphia*.

OPOBALSAM. The most precious of the balsams is that commonly called Balm of Gilead, Opobalsamum, Balsamæleon, Balsamum verum album, Ægyptiacum, Judaicum, Syriacum e Mecca, &c. This is the produce of the amyris opobalsamum, L. The true balsam is of a pale yellowish colour, clear and transparent, about the consistence of Venice turpentine, of a strong, penetrating, agreeable, aromatic, smell, and a slightly bitterish pungent taste. By age it becomes yellower, browner, and thicker, losing by degrees, like volatile oils, some of its finer and more subtile parts. To spread, when dropped into water, all over the surface, and to form a fine, thin, rainbow-coloured cuticle, so tenacious that it may be taken up entire by the point of a needle, were formerly infallible criteria of the genuine opobalsam. Neumann, however, had observed, that other balsams, when of a certain degree of consistence, exhibit these phenomena equally with the Egyptian. According to Bruce, if dropped on a woollen cloth, in its pure and fresh state, it may be washed out completely and readily with simple water.

OPODELDOC. A solution of soap in alcohol, with the addition of camphor, and volatile oils. It is used externally against rheumatic pains, sprains, bruises, and other like complaints.

OPOPANAX. A concrete gummy resinous juice, obtained from the roots of an umbelliferous plant, the pastinaca opopanax, which grows spontaneously in the warmer countries, and bears the cold of this. The juice is brought from Turkey and the East Indies, sometimes in round drops or tears, but more commonly in irregular lumps, of a reddish-yellow colour on the outside, with specks of white; inwardly of a paler colour, and frequently variegated with large white pieces. It has a peculiar strong smell, and a bitter, acrid, somewhat nauseous taste.

ORES. Are the metals in their crude state, combined with oxygen, or mixed with clay, sand, or other earthy substances. The following are the situations in which metallic ores are found:—Platina and the recently discovered metals called palladium, rhodium, osmium, and iridium, have only been discovered in the sands of rivers. Gold and silver are found in primary and transition rocks, in porphyry and sienite, and in the lowest sand-stone. Gold has been occasionally discovered in coal, and very abundantly in the sands of rivers. Mercury is found in slate, in limestone, and in coal strata. Copper, in primary and transition rocks, in porphyry and sienite, and occasionally in sand-stone, in coal strata, and alluvial ground. Masses of native copper of many thousand pounds weight are found on the surface in the interior of North America. Iron in every kind of rock. Tin, in granite, gneiss, mica-slate, and slate. Lead and zinc, in primary and transition rocks, except trap and serpentine; in porphyry and sienite; in the lowest sand-stone, and occasionally in coal strata. Antimony, in primary and transition mountains, except in trap and serpentine; it is also found in porphyry and sienite. Nickel, bismuth, cobalt, in primary mountains, except lime-stone, trap, and serpentine. Cobalt and nickel also occur in transition mountains, and in sand-stone. Arsenic, in primary and transition mountains, and in porphyry. Manganese, in primary and transition mountains, and occasionally in the lower stratified rocks. Molybdena and tungsten, uranium and titanium, in granite, gneiss, mica-slate, and slate. The latter metals, with chromium, columbium, cerium, and tellurium, are very rare in nature, and can only be reduced to the metallic state with great

difficulty. According to the disciples of Werner, flinty slate is not metalliferous; which is the more remarkable, as this is a very abundant rock, and is traversed by veins of quartz. It also alternates with, and graduates insensibly into slate and gray wacke, the most metalliferous rocks. This offers a further proof, if any were wanting, that the nature of rocks influences the quality and quantity of the ores they contain.

ORICHALCUM, a mixture of copper and zinc, much the same as our brass used by the ancients. The æs was a kind of bronze.

ORPIMENT. A sulphuret of arsenic.

ORTHITE. A mineral which always occurs in straight layers, and generally in felspar. It consists of peroxide of cerium 19·5, protoxide of iron 12·44, protoxide of manganese 3·44, yttria 3·44, silica 33·0, alumina 14·8, lime 7·14, water 5·36.

OSMAZOME. A peculiar animal principle obtained by digesting cold water on slices of raw muscular fibre which is occasionally to be pressed. It is to be evaporated, filtered, and treated with alcohol. It has a brownish colour, and the taste and smell of soup.

OSMIUM. A new metal lately discovered by Mr. Tennant among platina, and thus called by him from the pungent and peculiar smell of its oxide. For the mode in which he extracted it, see *Iridium*. Its oxide may likewise be obtained in small quantity by distilling with nitre the black powder left after dissolving platina; when at a low red-heat an apparently oily fluid sublimes into the neck of the retort, which, on cooling, concretes into a solid, colourless, semi-transparent mass. This being dissolved in water, forms a concentrated solution of oxide of osmium. This solution gives a dark stain to the skin that cannot be effaced. Infusion of galls presently produces a purple colour in it, which soon after becomes of a deep vivid blue. This is the best test of the oxide. With pure ammonia it becomes yellow, and slightly so with carbonate of soda. With lime it forms a bright yellow solution; but it is not affected either by chalk or by pure magnesia. The solution with lime gives a deep red precipitate with galls, which is turned blue by acids. It produces no effect on solution of gold or platina; but precipitates lead of a yellowish-brown, mercury of a white, and muriate of tin of a brown colour. Oxide of osmium becomes of a dark colour with alcohol, and after some time separates in the form of black films, leaving the alcohol without colour. The same effect is produced by ether, and much more quickly. It parts with its oxygen to all the metals, except gold and platina. Silver kept in a solution of it some time, acquires a black colour, but does not deprive it entirely of smell. Copper, tin, zinc, and phosphorus, quickly produce a black or grey powder, and deprive the solution of smell, and of the property of turning galls blue. This black powder, which consists of the metallic osmium, and the oxide of the metal employed to precipitate it, may be dissolved in nitro-muriatic acid, and then become blue with infusion of galls. If the pure oxide dissolved in water be shaken with mercury, it soons loses its smell, and the metal forms a perfect amalgam. By squeezing the superfluous mercury through leather, and distilling off the rest, a dark grey or blue powder is left, which is the osmium. Exposed to a strong heat in a cavity in a piece of charcoal, it does not melt; nor is it volatile if oxidation be carefully prevented. With copper and with gold it forms malleable alloys, which are easily dissolved in nitro-muriatic acid, and afford, by distillation the oxide of osmium. The pure metal, previously heated, did not appear to be acted upon by acids. Heated in a silver cup with caustic alkali, it combined with it, and gave a yellow solution, similar to that from which it was procured. From this solution acids separate the oxide of osmium.

OSSIFICATION. The deposition of the phosphate and carbonate of lime on the soft solids of animal bodies, as on the lungs, liver, heart, &c.

OXALATES. Compounds of salifiable bases with the oxalic acid.

OXALIC ACID. This acid, which abounds in wood sorrel, and which, combined with a small portion of potash, as it exists in that plant, has been sold under the name of salt of

lemons, to be used as a substitute for the juice of that fruit, particularly for discharging ink spots and iron-moulds, was long supposed to be analogous to that of tartar. In the year 1776, however, Bergman discovered, that a powerful acid might be extracted from sugar by means of the nitric; and a few years afterwards Scheele found this to be identical with the acid existing naturally in sorrel. Hence the acid began to be distinguished by the name of saccharine, but has since been known in the new nomenclature by that of oxalic. Scheele extracted this acid from the salt of sorrel, or acidulous oxalate of potash, as it exists in the juice of that plant, by saturating it with ammonia, when it becomes a very soluble triple salt, and adding to the solution nitrate of barytes dissolved in water. Having well washed the oxalate of barytes, which is precipitated, he dissolved it in boiling water, and precipitated its base by sulphuric acid. To ascertain that no sulphuric acid remained in the supernatant liquor, he added a little of a boiling solution of oxalate of barytes till no precipitate took place, and then filtered the liquor, which contained nothing but pure oxalic acid, which he crystallized by evaporation and cooling. It may be obtained, however, much more readily and economically from sugar in the following way: To six ounces of nitric acid in a stoppered retort, to which a large receiver is luted, add, by degrees, one ounce of lump sugar coarsely powdered. A gentle heat may be applied during the solution, and nitric oxide will be evolved in abundance. When the whole of the sugar is dissolved, distil off a part of the acid, till what remains in the retort has a syruppy consistence, and this will form regular crystals, amounting to 58 parts from 100 of sugar. These crystals must be dissolved in water, re-crystallized, and dried on blotting-paper. A variety of other substances afford the oxalic acid when treated by distillation with the nitric. Bergman procured it from honey, gum arabic, alcohol, and the calculous concretions in the kidneys and bladders of animals. Scheele and Hermbstadt from sugar of milk. Scheele, from a sweet matter contained in fat oils, and also from the uncrystallizable part of the juice of lemons. Hermbstadt, from the acid of cherries, and the acid of tartar. Goetling, from beech wood. Kohl, from the residuum in the distillation of ardent spirits. Westrumb, not only from the crystallized acids of currants, cherries, citrons, raspberries, but also from the saccharine matter of these fruits, and from the uncrystallizable parts of the acid juices. Hoffmann, from the juice of the barberry; and Berthollet, from silk, hair, tendons, wool; also from other animal substances, especially from the coagulum of blood, whites of eggs, and likewise from the amylaceous and glutinous parts of flour. M. Berthollet observes, that the quantity of the oxalic acid obtained by treating wool with nitric acid was very considerable, being above half the weight of the wool employed. He mentions a difference which he observed between animal and vegetable substances thus treated with nitric acid, namely, that the former yielded, beside ammonia, a large quantity of an oil which the nitric acid could not decompose; whereas the oily parts of vegetables were totally destroyed by the action of this acid: and he remarks, that in this instance the glutinous part of flour resembled animal substances, whereas the amylaceous part of the flour retained its vegetable properties. He further remarks, that the quantity of oxalic acid furnished by vegetable matters thus treated is proportionable to their nutritive quality, and particularly that, from cotton, he could not obtain any sensible quantity. Deyeux, having cut with scissars the hairs of the chick pea, found they gave out an acid liquor, which, on examination, proved to be an aqueous solution of pure oxalic acid. Proust and other chemists had before observed, that the shoes of persons walking through a field of chick pease were corroded. Oxalic acid crystallizes in quadrilateral prisms, the sides of which are alternately broad and narrow, and summits diedral; or, if crystallized rapidly, in small irregular needles. They are efflorescent in dry air, but attract a little humidity if it be damp; are soluble in one part of hot and two of cold water; and are decomposable by a red heat, leaving a small quantity of coally residuum.—100 parts of

alcohol take up near 56 at a boiling heat, but not above 40 cold. Their acidity is so great, that when dissolved in 3600 times their weight of water, the solution reddens litmus paper, and is perceptibly acid to the taste. The oxalic acid is a good test for detecting lime, which it separates from all the other acids, unless they are present in excess. It has likewise a greater affinity for lime than for any other of the bases, and forms with it a pulverulent insoluble salt, not decomposable except by fire, and turning syrup of violets green. Oxalic acid acts as a violent poison when swallowed in the quantity of two or three drachms; and several fatal accidents have lately occurred, in consequence of its being improperly sold instead of Epsom salts. The immediate rejection from the stomach of this acid, by an emetic, aided by copious draughts of warm water containing bicarbonate of potash, or soda, chalk, or carbonate of magnesia, are the proper remedies. With barytes it forms an insoluble salt; but this salt will dissolve in water acidulated with oxalic acid, and afford angular crystals. If, however, we attempt to dissolve these crystals in boiling water the excess of acid will unite with the water, and leave the oxalate, which will be precipitated. The oxalate of strontian too is a nearly insoluble compound. Oxalate of magnesia too is insoluble, unless the acid be in excess. The oxalate of potash exists in two states, that of a neutral salt, and that of an acidule. The latter is generally obtained from the juice of the leaves of the oxalis acetosella, wood sorrel, or rumex acetosa, common sorrel. The expressed juice, being diluted with water, should be set by for a few days, till the feculent parts have subsided, and the supernatant fluid is become clear; or it may be clarified, when expressed, with the whites of eggs. It is then to be strained off, evaporated to a pellicle, and set in a cool place to crystallize. The first product of crystals being taken out, the liquor may be further evaporated, and crystallized; and the same process repeated till no more can be obtained. In this way Schlereth informs us about nine drachms of crystals may be obtained from two pounds of juice, which are generally afforded by ten pounds of wood sorrel. Savary, however, says, that ten parts of wood sorrel in full vegetation yield five parts of juice, which give little more than a two hundredth of tolerably pure salt. He boiled down the juice, however, in the first instance, without clarifying it; and was obliged repeatedly to dissolve and recrystallize the salt to obtain it white. This salt is in small, white, needly, or lamellar crystals, not alterable in the air. It unites with barytes, magnesia, soda, ammonia, and most of the metallic oxides, into triple salts. Yet its solution precipitates the nitric solutions of mercury and silver in the state of insoluble oxalate of these metals, the nitric acid in this case combining with the potash. It attacks iron, lead, tin, zinc, and antimony. This salt, beside its use in taking out ink spots, and as a test of lime, forms with sugar and water a pleasant cooling beverage; and according to Berthollet, it possesses considerable powers as an antiseptic. The neutral oxalate of potash is very soluble, and assumes a gelatinous form, but may be brought to crystallize in hexaëdral prisms with diëdral summits, by adding more potash to the liquor than is sufficient to saturate the acid. Oxalate of soda likewise exists in two different states, those of an acidulous and a neutral salt, which in their properties are analogous to those of potash. The acidulous oxalate of ammonia is crystallizable, not very soluble, and capable, like the preceding acidules, of combining with other bases, so as to form triple salts. But if the acid be saturated with ammonia, we obtain a neutral oxalate, which, on evaporation, yields very fine crystals in tetraëdral prisms with diëdral summits, one of the planes of which, cuts off three sides of the prism. This salt is decomposable by fire, which raises from it a carbonate of ammonia, and leaves only some slight traces of a coally residuum. Lime, barytes, and strontian unite with its acid, and the ammonia flies off in the form of gas. The oxalic acid readily dissolves alumina, and the solution gives, on evaporation, a yellowish transparent mass, sweet and a little astringent to the taste, deliquescent, and reddening tincture of litmus, but not of syrup of violets.

This salt swells up in the fire, loses its acid, and leaves the alumina a little coloured. The oxalic acid may be obtained from the roots and bark of innumerable plants.

OXIDATION. The process of converting metals, or other substances, into oxides, by combining with them a certain portion of oxygen. It differs from acidification in the addition of oxygen not being sufficient to form an acid with the substance oxided.

OXIDES. Substances combined with oxygen, without being in the state of an acid.

OXY-ACETIC ACID is obtained by dissolving the deutoxide of barium in acetic acid. It is the acetic deutoxide of hydrogen.

OXYGEN GAS. This gas was obtained by Dr. Priestly in 1774, from red oxide of mercury exposed to a burning lens, who observed its distinguishing properties of rendering combustion more vivid and eminently supporting life. Scheele obtained it in different modes in 1775; and in the same year Lavoisier, who had begun, as he says, to suspect the absorption of atmospheric air, or of a portion of it, in the calcination of metals, expelled it from the red oxide of mercury heated in a retort. Oxygen gas forms about a fifth of our atmosphere, and its base is very abundant in nature. Water contains 88·88 per cent. of it; and it exists in most vegetable and animal products, acids, salts, and oxides. This gas may be obtained from nitrate of potash, exposed to a red-heat in a coated glass or earthen retort, or in a gun-barrel: from a pound of which about 1200 cubic inches may be obtained; but this is liable, particularly toward the end of the process, to a mixture of nitrogen. It may be expelled, as already observed, from the red oxide of mercury or that of lead; and still better from the black oxide of manganese, heated red-hot in a gun-barrel, or exposed to a gentler heat in a retort with half its weight, or somewhat more, of strong sulphuric acid. To obtain it of the greatest purity, however, the chlorate of potash is preferable to any other substance, rejecting the portions that first come over as being debased with the atmospheric air in the retort. Growing vegetables, exposed to the solar light, give out oxygen gas; so do leaves laid on water in similar situations, the green matter that forms in water, and some other substances. Oxygen gas has neither smell nor taste. Its sp. gr. is 1·1111; 100 cubic inches weigh 33·88 gr. It is a little heavier than atmospheric air. Under great pressure water may be made to take up about half its bulk. It is essential to the support of life: an animal will live in it a considerable time longer than in atmospheric air; but its respiration becomes hurried and laborious before the whole is consumed, and it dies, though a fresh animal of the same kind can still sustain life for a certain time in the residuary air. Combustion is powerfully supported by oxygen gas. Any inflammable substance, previously kindled, and introduced into it, burns rapidly and vividly. If an iron or copper wire be introduced into a bottle of oxygen gas, with a bit of lighted touchwood or charcoal at the end, it will burn with a bright light, and throw out a number of sparks. The bottom of the bottle should be covered with sand, that these sparks may not crack it. If the wire be coiled up in a spiral like a corkscrew, as it usually is in this experiment, and moved with a jerk the instant a melted globule is about to fall, so as to throw it against the side of the glass, it will melt its way through in an instant; or, if the jerk be less violent, lodge itself in the substance of the glass. If it be performed in a bell glass, set in a plate filled with water, the globules will frequently fuse the vitreous glazing of the plate, and unite with it so as not to be separable without detaching the glaze, though it has passed through perhaps two inches of water.

OXYGENATION. This word is often used instead of oxidation, and frequently confounded with it; but it differs in being of more general import, as every union with oxygen, whatever the product may be, is an oxygenation; but oxidation takes place only when an oxide is formed.

OXYMEL. A compound of honey and vinegar.

OXYMURIATES. Compounds of the chloric acid with salifiable bases. The oxymuriate of mercury is corrosive sublimate. The oxymuriate or chloride of alumina, has been used in discharging Turkey red.

OXYMURIATIC ACID. Chlorine.

OXYPRUSSIC ACID. See *Prussic Acid.*

P.

PABULUM OF PLANTS. Plants are found by analysis to consist principally of charcoal and aeriform matter. They give out by distillation volatile compounds, the elements of which are pure air, inflammable air, coally matter, and azote, or that elastic substance which forms a great part of the atmosphere, and which is incapable of supporting combustion. These elements they gain either by their leaves from the air, or by their roots from the soil. All manures from organized substances contain the principles of vegetable matter, which during putrefaction are rendered either soluble in water or aeriform—and in these states they are capable of being assimilated to the vegetable organs. No one principle affords the pabulum of vegetable life; it is neither charcoal nor hydrogen, nor azote nor oxygen alone; but all of them together in various states and various combinations. Organic substances as soon as they are deprived of vitality, begin to pass through a series of changes, which ends in their complete destruction, and in the entire separation and dissipation of the parts. Animal matters are the soonest destroyed by the operation of air, heat, and light. Vegetable substances yield more slowly, but finally obey the same laws. The periods of the application of manures from decomposing animal and vegetable substances depend upon the knowledge of these principles.

PALLADIUM. This is a new metal, first found by Dr. Wollaston associated with platina, among the grains of which he supposes its ore to exist, or an alloy of it with iridium and osmium, scarcely distinguishable from the crude platina, though it is harder and heavier. If crude platina be dissolved in nitro-muriatic acid, and precipitated with a solution of muriate of ammonia in hot water; the precipitate washed, and the water added to the remaining solution, and a piece of clean zinc be immersed in this liquid, till no farther action on it takes place; the precipitate now thrown down will be a black powder, commonly consisting of platina, palladium, iridium, rhodium, copper, and lead. The lead and copper may be separated by dilute nitric acid. The remainder being then digested in nitro-muriatic acid, and common salt about half the weight of the precipitate added on the solution, on evaporating this to dryness by a gentle heat, the result will be triple salts of muriate of soda with platina, palladium, and rhodium. Alcohol will dissolve the first and second of these; and the small portion of platina may be precipitated by sal ammoniac. The solution being diluted, and prussiate of potash added, a precipitate will be thrown down, at first a deep orange, and afterward changing green. This being dried, and healed with a little sulphur before the blow-pipe, fuses into a globule, from which the sulphur may be expelled by exposing it to the extremity of the flame, and the palladium will remain spongy and malleable. It may likewise be obtained by dissolving an ounce of nitrate of potash in five of muriatic acid, and in this mixture digesting the compound precipitate mentioned above. Or more simply, by adding to a solution of crude platina, a solution of prussiate of mercury, on which a flocculent precipitate will gradually be formed, of a yellowish-white colour. This is prussiate of palladium, from which the acid may be expelled by heat. Palladium is of a greyish-white colour, scarcely distinguishable from platina, and takes a good polish. It is ductible and very malleable; and being reduced into thin slips is flexible, but not very elastic. Its fracture is fibrous, and in diverging striæ, showing a kind of crystalline arrangement. In hardness it is superior to wrought iron. Its sp. grav. is from 10·9 to 11·8. It is a less perfect conductor of caloric than most metals, and less expansible, though in this it exceeds platina. On exposure to a strong heat its surface tarnishes a little, and becomes blue; but an increased heat brightens it again. It is reducible *per se*. Its fusion requires a much higher heat than that of gold;

but if touched while hot with a small bit of sulphur, it runs like zinc. The sulphuret is whiter than the metal itself, and extremely brittle. Nitric acid soon acquires a fine red colour from palladium, but the quantity it dissolves is small. Nitrous acid acts on it more quickly and powerfully. Sulphuric acid, by boiling, acquires a similar colour, dissolving a small portion. Muriatic acid acts much in the same manner. Nitro-muriatic acid dissolves it rapidly, and assumes a deep red. Alkalis and earths throw down a precipitate from its solutions generally of a fine orange colour: but it is partly re-dissolved in an excess of alkali. Some of the neutral salts, particularly those of potash, form with it triple compounds, much more soluble in water than those of platina, but insoluble in alcohol. Alkalis act on palladium even in the metallic state; the contact of air, however, promotes their action. A neutralised solution of palladium is precipitated of a dark orange or brown by recent muriate of tin: but if it be in such proportions as to remain transparent, it is changed to a beautiful emerald-green. Green and sulphate of iron precipitates the palladium in a metallic state. Sulphuretted hydrogen produces a dark brown precipitate; prussiate of potash an olive-coloured; and prussiate of mercury a yellowish-white. As the last does not precipitate platina, it is an excellent test of palladium. This precipitate is from a neutral solution in nitric acid, and detonates at about 500° of Fahr. in a manner similar to gunpowder. Fluoric, arsenic, phosphoric, oxalic, tartaric, citric, and some other acids, with their salts, precipitate some of the solutions of palladium.

PASTE. Imitations of gems are so called. Such substances are selected, to be fused together, as will produce an artificial glass, resembling in appearance the gem intended, and sufficiently hard and beautiful. The art has been brought to such perfection that it requires a very close inspection of the skilful to be able to distinguish the real from the apparent. The art is much encouraged, not only by the vain, who are unable, ever to procure real gems, but also to replace for a time the diamonds of such persons as find it convenient to procure a temporary loan by pledging their jewels. Silex, borax, red oxide of lead, potass, and sometimes arsenic, are the base of all artificial stones. The fusion should be kept up moderately for twenty-four hours together. This will give what has been called simply Paste or Strass. The following three mixtures give a very fine strass.

	1st.	2d.	3d.
Rock crystal	0·318	0·3170	0·300
Minium - -	0·490	0·4855	0·565
Potash (pure)	0·170	0·1770	0·105
Borax - -	0·021	0·0200	0·030
Arsenic (oxide of)	0·001	0·0005	—
	1·000	1·000	1·000

Mr. Lançon recommends the following:—

Litharge - -	0·546
White lead - -	0·406
White tartar, or potass	0·054
	1·000

Topaz is difficult of imitation. The following are the receipts:—

White strass - -	0·95816	99
Glass of antimony -	0·04089	—
Purple of cassias -	0·00095	—
Oxide of iron - -	—	0.01
	1·000	1·000

Ruby is thus made:—

Strass - - - -	0·9755
Oxide of Manganese	0·0245
	1·0000

Emerald is very easily made:—

Strass - - - - -	0·98743
Green oxide of copper -	0·01200
Oxide of chromium -	0·00057
	1·0000

Mr. Lançon's receipt is—

Strass - - -	0.9905
Acetate of copper -	0·0080
Peroxide of iron -	0·0016
	1 0000

By augmenting the oxides of copper and chromium in the first of the above, and adding oxide of iron, we may vary the green shades, and imitate deep-coloured emerald.—Sapphire is thus composed:—

Strass (very white)	-	0·9855
Oxide of cobalt	-	0·0145
		1·0000

This mixture must be put into a Hessian crucible, and remain in the fire thirty hours.—Amethyst is thus obtained :—

Strass	- - - -	0·9870
Oxide of manganese		0·0078
Oxide of cobalt	-	0·0050
Purple of cassias	-	0·0002
		1·0000

Mr. Lançon uses—

Strass	- - - -	0.9977
Oxide of manganese		0.0022
Oxide of cobalt	-	0·0001
		1.0000

Beryl or Aquamarine is thus made :

Strass	- - - -	0 9926
Glass of antimony	-	0.0070
Oxyde of cobalt	-	0 0001
		1·0000

Syrian garnet is used for small jewels, and is thus made :—

Strass	- - - -	0·6630
Glass of antimony	-	0·3320
Purple of cassias	-	0·0025
Oxide of manganese		0·0025
		1·0000

In making pastes, the materials should be carefully pulverized, well sifted, and the same sieve not used to different compositions, and only the purest materials should be used, and the best crucibles : a uniform heat should be kept up for 24 or 30 hours, and the mass should be left to cool gradually.

PARGASITE, actinolite.

PEAS. 3840 parts of ripe peas afforded sir H. Davy of—

		parts.
Starch	- - - - -	1265
Fibrous matter analogous to starch, with the coats of the peas		840
A substance analogous to gluten		550
Mucilage	- - - - -	249
Saccharine matter	- -	81
Albumen	- - - - -	66
Volatile matter	- -	540
Earthy phosphates	- -	11
Loss	- - - - - -	229

PEARL, a concretion formed in certain shell-fish. It is of a bluish-white colour, with considerable lustre and irridescence. It consists of alternate layers of membrane and carbonate of lime, which occasions their irridescence. Pearls are soluble in acids. It is related of Cleopatra, that, in the intoxication of her prosperity, she took a pearl of immense value, dissolved it, and drank it in the presence of Antony.

PEAT, is one of the most important productions of alluvial ground; it may be regarded as belonging more properly to the vegetable than the mineral kingdom. Peat formerly covered extensive tracts in England, but is disappearing before the genius of agricultural improvement, which has no where produced more important effects than in the conversion of the black and barren peat moors of the northern counties into valuable land covered with luxuriant herbage, and depastured by numerous flocks. The following description of the peat moors in Scotland, by Mr. Jameson, is an accurate picture of the remaining peat moors in the mountainous parts of Yorkshire and the adjoining counties :—In describing the general appearance of a peat moor, we may conceive an almost entire flat of several miles extent, of a brown colour, here and there marked with tufts of heather, which have taken root, owing to the more complete decomposition of the surface peat ; no tree or shrub is to be seen ; not a spot of grass to relieve the eye in wandering over this dreary scene. A nearer examination discovers a wet spungy surface, passable only in the driest seasons, or when all nature is locked in frost. The surface is frequently covered with a slimy black-coloured substance, which is the peat earth, so mixed with water, as to render the moss only passable by leaping from one tuft of heather to another. Sometimes, however, the surface of peat mosses has a different aspect, owing to the greater abundance of heath and other vegetables, as the schœni, scirpi, eriophora, &c.; but this is principally the case with some kinds of what are called muirlands, which contain but little peat, being nearly composed of the interwoven roots of living vegetables. Quick moss (as it is called) is a substance of a more or less brown colour, forms a kneadable compound,

and when good, cuts freely and clean with the spade; but when it resists the spade by a degree of elasticity, it is found to be less compact when dried, and is of an inferior quality. The best kinds burn with a clear bright flame, leaving light-coloured ashes; but the more indifferent kinds in burning often emit a disagreeable smell, and leave a heavy red-coloured kind of ashes. In digging the peat, we observe that, when first taken from the pit, it almost immediately changes its colour, which becomes more or less a deep brown or black, and the peat matter becomes much altered, being incapable of forming a kneadable paste with water. When dry and reduced to powder, as it is often by the action of the weather, it forms a blackish-coloured powdery matter, capable of supporting vegetation when calcareous earth is added. Peat is found in various situations, often in valleys or plains, where it forms very extensive deep beds, from three to forty feet deep, as those in Aberdeenshire; it also occurs upon the sides of mountains; but even there it is generally in a horizontal situation. The tops of mountains, upwards of 2,000 feet high, in the Highlands of Scotland, are covered with peat of an excellent kind. In Germany it is also found at very great heights; thus, the Blogsberg, a high mountain in Lower Saxony, and the Brohen, the highest mountain of the Hartz, are also covered with peat. It is also found in situations nearly upon a level with the sea: thus, the great moss of Cree in Galloway lies close upon the sea, on a bed of clay, little higher than the flood marks at spring tides.

PEARLASH, an impure potash, obtained from the ashes of burnt vegetables.

PEARL SPAR. See *Brown Spar*.

PEARL STONE, a kind of quartz, found near Tokay, in Hungary.

PEARL SINTER, or **FIORITE**, consists of silica 94, alumina 2, lime 4.

PEA STONE, a sub-species of limestone.

PECHBLENDE. An ore of uranium.

PERCHLORIC ACID. See *Muriatic Acid*.

PERICARDIUM (Liquor of the). The constituents of the liquor pericardii appear to be—

Water -	- 92·0	
Albumen	- 5·5	
Mucus	- 2·0	The proportion of these substances is somewhat conjectural.
Muriate of soda	0.5	
	100·0	

PERIDOT, chrysolite

PERLATE ACID. This name was given by Bergmann to the acidulous phosphate of soda

PERLATED ACID, biphosphurate of soda.

PERU (*Balsam of*). This substance is obtained from the myroxylon peruiferum, which grows in the warm parts of South America. The tree is full of resin, and the balsam is obtained by boiling the twigs in water. It has the consistency of honey, a brown colour, an agreeable smell, and a hot acrid taste.

PERUVIAN BARK. See *Cinchona*.

PETALITE, a mineral found in the mine Uto in Sweden, the analysis of which led to the discovery of a new alkali, lithia. Its constituents are, silex 79·212, alumina 16·225, lithia 5·761. See *Lithia*.

PETRIFACTIONS. Stony matters deposited either in the way of incrustation, or within the cavities of organized substances, are called petrifactions. Calcareous earth being universally diffused and capable of solution in water, either alone, or by the medium of carbonic acid or sulphuric acid, which are likewise very abundant, is deposited whenever the water or the acid becomes dissipated. In this way we have incrustations of limestone or of selenite in the form of stalactites or dropstones from the roofs of caverns, and in various other situations. The most remarkable observations relative to petrifactions are thus given by Kirwan:—

1. That those of shells are found on, or near, the surface of the earth; those of fish deeper, and those of wood deepest. Shells in specie are found in immense quantities at considerable depths.

2. That those organic substances that resist putrefaction most, are frequently found petrified; such as shells and the harder species of

woods: on the contrary, those that are aptest to putrefy, are rarely found petrified; as fish, and the softer parts of animals, &c.

3. That they are most commonly found in strata of marle, chalk, limestone, or clay; seldom in sandstone, still more rarely in gypsum: but never in gneiss, granite, basaltes, or shorle; but they sometimes occur among pyrites, and ores of iron, copper, and silver, and almost always consist of that species of earth, stone, or other mineral that surrounds them, sometimes of silex, agate, or carnelian.

4. That they are found in climates where their originals could not have existed.

5. That those found in slate or clay are compressed and flattened.

PETROLEUM, the same as naphtha.

PETROSILEX, compact felspar.

PETUNTSE, porcelain clay used by the Chinese.

PEWTER, which is commonly called étain in France, and generally confounded there with true tin, is a compound metal, the basis of which is tin. The best sort consists of tin alloyed with about a twentieth, or less, of copper, or other metallic bodies, as the experience of the workmen has shown to be the most conducive to the improvement of its hardness and colour, such as lead, zinc, bismuth, and antimony. There are three sorts of pewter, distinguished by the names of plate, trifle, and ley-pewter. The first was formerly much used for plates and dishes; of the second are made the pints, quarts, and other measures of beer; and of the ley-pewter, wine measures, and large vessels. The best sort of pewter consists of 17 parts of antimony to 100 parts of tin; but the French add a little copper to this kind of pewter. A very fine silver-looking metal is composed of 100 pounds of tin, eight of antimony, one of bismuth, and four of copper. On the contrary, the ley-pewter, by comparing its specific gravity with those of the mixtures of tin and lead, must contain more than a fifth part of its weight of lead.

PHARMACOLITE, a native combination of arsenic of iron.

PHOSPHORESCENCE, a light resembling that of phosphorus.

PHOSPHORITE, a sub-species of apatite. Common phosphorite consists of lime 59, phosphoric acid 34, silica 2, fluoric acid 1, oxide of iron 1. Earthy phosphorite contains 11·5 of quartz and loam.

PHOSPHORIC ACID. The base of this acid, or the acid itself, abounds in the mineral, vegetable, and animal kingdoms. In the mineral kingdom it is found in combination with lead, in the green lead ore, with iron, in the bog ores which afford cold short iron; and more especially with calcareous earth in several kinds of stone. Whole mountains in the province of Estremadura, in Spain, are composed of this combination of phosphoric acid and lime. Mr. Bowles affirms, that the stone is whitish and tasteless, and affords a blue flame without smell when thrown upon burning coals. Mr. Proust describes it as a dense stone, not hard enough to strike fire with steel, and says that it is found in strata, which always lie horizontally upon quartz, and which are intersected with veins of quartz. When this stone is scattered upon burning coals, it does not decrepitate, but burns with a beautiful green light, which lasts a considerable time. It melts into a white enamel by the blow-pipe; is soluble with heat, and some effervescence in the nitric acid, and forms sulphate of lime with the sulphuric acid, while the phosphoric acid is set at liberty in the fluid. The vegetable kingdom abounds with phosphorus, or its acid. It is principally found in plants that grow in marshy places, in turf, and several species of the white woods. Various seeds, potatoes, agaric, soot, and charcoal, afford phosphoric acid by abstracting the nitric acid from them, and lixiviating the residue. The lixivium contains the phosphoric acid, which may either be saturated with lime by the addition of lime water, in which case it forms a solid compound; or it may be tried by examination of its leading properties by other chemical methods. In the animal kingdom it is found in almost every part of the bodies of animals which are not considerably volatile. There is not, in all probability, any part of these organized beings which is free from it. It has been obtained from blood, flesh, both of land and water animals; from cheese; and it exists in large quantities in bones, combined

with calcareous earth. Urine contains it, not only in a disengaged state, but also combined with ammonia, soda, and lime. It was by the evaporation and distillation of this excrementitious fluid with charcoal that phosphorus was first made; the charcoal decomposing the disengaged acid and the ammoniacal salt.—(See *Phosphorus.*) But it is more cheaply obtained by the process of Scheele, from bones, by the application of an acid to their earthy residue after calcination. In this process the sulphuric acid appears to be the most convenient, because it forms a nearly insoluble compound with the lime of the bones. Bones of beef, mutton, or veal, being calcined to whiteness in an open fire, lose almost half of their weight. This must be pounded and sifted, or the trouble may be spared by buying the powder that is sold to make cupels for the assayers, and is, in fact, the powder of burned bones ready sifted. To three pounds of powder there may be added about two pounds of concentrated sulphuric acid. Four or five pounds of water must be afterwards added, to assist the action of the acid; and during the whole process the operator must remember to place himself and his vessels so that the fumes may be blown from him. The whole may be then left on a gentle sand bath for twelve hours or more, taking care to supply the loss of water which happens by evaporation. The next day a large quantity of water must be added, the whole strained through a sieve, and the residual matter, which is sulphate of lime, must be edulcorated by repeated affusions of hot water, till it passes tasteless. The waters contain phosphoric acid nearly free from lime, and by evaporation, first in glazed earthen, and then in glass vessels, or rather in vessels of platina or silver, for the hot acid acts upon glass, afford the acid in a concentrated state, which, by the force of a strong heat in a crucible, may be made to acquire the form of a transparent consistent glass, though indeed it is usually of a milky, opaque appearance. For making phosphorus, it is not necessary to evaporate the water further than to bring it to the consistence of syrup; and the small portion of lime it contains is not an impediment worth the trouble of removing, as it affects the produce very little. But when the acid is required in a purer state, it is proper to add a quantity of carbonate of ammonia, which, by double elective attraction, precipitates the lime that was held in solution by the phosphoric acid. The fluid being then evaporated, affords a crystallized ammoniacal salt, which may be melted in a silver vessel, as the acid acts upon glass or earthen vessels. The ammonia is driven off by the heat, and the acid acquires the form of a compact glass as transparent as rock crystal, acid to the taste, soluble in water, and deliquescent in the air. This acid is commonly pure, but nevertheless may contain a small quantity of soda, originally existing in the bones, and not capable of being taken away by this process, ingenious as it is. The only unequivocal method of obtaining a pure acid, appears to consist in first converting it into phosphorus by distillation of the materials with charcoal, and then converting it again into acid by rapid combustion, at a high temperature, either in oxygen or atmospheric air, or some other equivalent process. Phosphorus may also be converted into the acid state by treating it with nitric acid. In this operation, a tubulated retort with a ground stopper, must be half filled with nitric acid, and a gentle heat applied. A small piece of phosphorus being then introduced through the tube will be dissolved with effervescence, produced by the escape of a large quantity of nitric oxide. The addition of phosphorus must be continued until the last piece remains undissolved. The fire being then raised to drive over the remainder of the nitric acid, the phosphoric acid will be found in the retort, partly in the concrete and partly in the liquid form. Sulphuric acid produces nearly the same effect as the nitric; a large quantity of sulphurous acid flying off. But as it requires a stronger heat to drive off the last portions of this acid, it is not so well adapted to the purpose. The liquid chlorine likewise acidifies it. When phosphorus is burned by a strong heat, sufficient to cause it to flame rapidly, it is almost perfectly converted into dry acid, some of which is thrown up by the force of the combustion, and the rest remains upon the supporter. This substance

has also been acidified by the direct application of oxygen gas passed through hot water, in which the phosphorus was liquefied or fused. The general characters of phosphoric acid are :—1. It is soluble in water in all proportions, producing a specific gravity, which increases as the quantity of acid is greater, but does not exceed 2·687, which is that of the glacial acid. 2. It produces heat when mixed with water, though not very considerable. 3. It has no smell when pure, and its taste is sour, but not corrosive. 4. When perfectly dry, it sublimes in close vessels, but loses this property by the addition of water ; in which circumstance it greatly differs from the boracic acid, which is fixed when dry, but rises by the help of water. 5. When considerably diluted with water, and evaporated, the aqueous vapour carries up a small portion of the acid. 6. With charcoal or inflammable matter, in a strong heat, it loses its oxygen, and becomes converted into phosphorus. Phosphoric acid is difficult of crystallizing. Though the phosphoric acid is scarcely corrosive, yet, when concentrated, it acts upon oils, which it discolours, and at length blackens, producing heat, and a strong smell like that of ether and oil of turpentine, but does not form a true acid soap. It has most effect on essential oils, less on drying oils, and least of all on fat oils. Spirit of wine and phosphoric acid have a weak action on each other. Some heat is excited by this mixture, and the product which comes over in distillation of the mixture is strongly acid, of a pungent arsenical smell, inflammable with smoke, miscible in all proportions with water, precipitating silver and mercury from their solutions, but not gold ; and although not an ether, yet it seems to be an approximation to that kind of combination. Phosphoric acid, united with barytes, produces an insoluble salt, in the form of a heavy white powder, fusible at a high temperature into a grey enamel. The best mode of preparing it is by adding an alkaline phosphate to the nitrate or muriate of barytes. The phosphate of strontian differs from the preceding in being soluble in an excess of its acid. Phosphate of lime is very abundant in the native state. At Marmarosch, in Hungary, it is found in a pulverulent form, mixed with fluate of lime. In the province of Estremadura, in Spain, it is in such large masses, that walls of enclosures, and even houses, are built with it ; and it is frequently crystallized, as in the apatite of Werner, when it assumes different tints of grey, brown, purple, blue, olive, and green. In the latter state, it has been confounded with the crysolite, and sometimes with the beryl and aqua marine, as in the stone called the Saxon beryl. It likewise constitutes the chief part of the bones of all animals. The phosphate of lime is very difficult to fuse, but in a glass-house furnace it softens, and acquires the semi-transparency and grain of porcelain. It is insoluble in water, but when well calcined, forms a kind of paste with it, as in making cupels. Besides this use of it, it is employed for polishing gems and metals, for absorbing grease from cloth, linen, or paper, and for preparing phosphorus. In medicine it has been strongly recommended against the rickets by Dr. Bouhoume, of Avignon, either alone or combined with phosphate of soda. The burnt hartshorn of the shops is a phosphate of lime. An acidulous phosphate of lime is found in human urine, and may be crystallized in small silky filaments, or shining scales, which unite together into something like the consistence of honey, and have a perceptibly acid taste. It may be prepared by partially decomposing the calcareous phosphate of bones by the sulphuric, nitric, or muriatic acid, or by dissolving that phosphate in phosphoric acid. It is soluble in water, and crystallizable. Exposed to the action of heat, it softens, liquefies, swells up, becomes dry, and may be fused into a transparent glass, which is insipid, insoluble, and unalterable in the air. In these characters it differs from the glacial acid of phosphorus. It is barely decomposable by charcoal, so as to afford phosphorus. The phosphate of potash is very deliquescent, and not crystallizable, but condensing into a kind of jelly. Like the preceding species, it first undergoes the aqueous fusion, swells, dries, and may be fused into a glass ; but this glass deliquesces. It has a sweetish saline taste. The phosphate of soda was first discovered combined with am-

monia in urine, by Schockwitz, and was called fusible, or microcosmic salt. Margraff obtained it alone by lixiviating the residuum left after preparing phosphorus from this triple salt and charcoal. Haupt, who first discriminated the two, gave the phosphate of soda the name of sal mirabile perlatum. Rouelle very properly announced it to be a compound of soda and phosphoric acid. Bergmann considered it, or rather the acidulous phosphate, as a peculiar acid, and gave it the name of perlate acid. Guyton-Morveau did the same, but distinguished it by the name of ouretic; at length Klaproth ascertained its real nature to be as Rouelle had affirmed. This phosphate is now commonly prepared by adding to the acidulous phosphate of lime as much carbonate of soda in solution as will fully saturate the acid. The carbonate of lime, which precipitates, being separated by filtration, the liquid is duly evaporated so as to crystallize the phosphate of soda; but if there be not a slight excess of alkali, the crystals will not be large and regular. M. Funcke, of Linz, recommends, as a more economical and expeditious mode, to saturate the excess of lime in calcined bones by dilute sulphuric acid, and dissolve the phosphate of lime that remains in nitric acid. To this solution he adds an equal quantity of sulphate of soda, and recovers the nitric acid by distillation. He then separates the phosphate of soda from the sulphate of lime by elutriation and crystallization, as usual. The crystals are rhomboidal prisms of different shapes; efflorescent; soluble in three parts of cold and one and a half of hot water. They are capable of being fused into an opaque white glass, which may be again dissolved and crystallized. It may be converted into an acidulous phosphate by an addition of acid, or by either of the strong acids, which partially, but not wholly, decompose it. As its taste is simply saline, without any thing disagreeable, it is much used as a purgative, chiefly in broth, in which it is not distinguishable from common salt. For this elegant addition to our pharmaceutical preparations, we are indebted to Dr. Pearson. In assays with the blow-pipe it is of great utility; and it has been used instead of borax for soldering. The phosphate of ammonia crystallizes in prisms with four regular sides, terminating in pyramids, and sometimes in bundles of small needles. Its taste is cool, saline, pungent, and urinous. On the fire it comports itself like the preceding species, except that the whole of its base may be driven off by a continuance of the heat, leaving only the acid behind. It is but little more soluble in hot water than in cold, which takes up a fourth of its weight. It is pretty abundant in human urine, particularly after it is become putrid. It is an excellent flux both for assays and the blow-pipe, and in the fabrication of coloured glass and artificial gems. Phosphate of magnesia crystallizes in irregular hexaedral prisms, obliquely truncated; but is commonly pulverulent, as it effloresces very quickly. It requires fifty parts of water to dissolve it. Its taste is cold and sweetish. This salt too is found in urine. Fourcroy and Vauquelin have discovered it likewise in small quantity in the bones of various animals, though not in those of man. The best way of preparing it is by mixing equal parts of the solutions of phosphate of soda and sulphate of magnesia, and leaving them some time at rest, when the phosphate of magnesia will crystallize, and leave the sulphate of soda dissolved. An ammoniaco-magnesian phosphate has been discovered in an intestinal calculus of a horse, by Fourcroy, and since by Bartholdi, and likewise by the former in some human urinary calculi. Notwithstanding the solubility of the phosphate of ammonia, this triple salt is far less soluble than the phosphate of magnesia. It is partially decomposable into phosphorus by charcoal, in consequence of its ammonia. The phosphate of glucine has been examined by Vauquelin, who informs us, that it is a white powder, or mucilaginous mass, without any perceptible taste; fusible, but not decomposable by heat; unalterable in the air; and insoluble unless in an excess of its acid. It has been observed, that the phosphoric acid, aided by heat, acts upon silex; and we may add, that it enters into many artificial gems in the state of a siliceous phosphate.

PHOSPHOROUS ACID. If phosphorus and corrosive sublimate be

made to act upon each other at an elevated temperature, a liquid called protochloride of phosphorus is formed. If water be added to this, it resolves it into muriatic and phosphorus acids. With a moderate heat the former is expelled, and the latter remains. When heated in an open vessel, it inflames, phosphuretted hydrogen flies off, and phosphoric acid remains. Hydrophosphorus acid is thus found:—Let water be poured on phosphuret of barytes, and wait till the phosphuretted hydrogen be disengaged. Then add cautiously to the filtered liquid dilute sulphuric acid, till the barytes be precipitated, and the supernatant liquid is hydrophosphorus acid, which should be passed through a filter, and may be concentrated by evaporation till it becomes viscid.

PHOSPHORUS, is a most extraordinary substance in nature, which has been rendered in some degree useful in common life, and affords much amusement by the wonderful experiments which by means of it may be performed. Like many other useful discoveries, it owes its origin to the vain search after the philosopher's stone, or the art of turning inferior metals into gold. The first person who made phosphorus was Brandt, an alchemist at Hamburgh, who obtained it by a very disagreeable process, in small quantities, from urine. It may be obtained now by more agreeable processes. Put half a pound of pulverised phosphoric acid into an earthen retort with the same quantity of charcoal previously mixed together; the beak of the retort must be a long one, and is to be immersed in a basin of cold water. Place the retort in a furnace, gradually heated, by putting in a small portion of fuel at first, and by adding more, until at last a white heat is obtained. Here the phosphoric acid will be decomposed, giving out its oxygen to the charcoal, which is thus converted into carbonic acid gas; this gas ascends through the water, and as it contains minute portions of phosphorus, (particularly if the distillation be rapid) combustion will take place as it arises from the surface of the water. The phosphorus will come over in a fluid state, and will fall down in congealed drops to the bottom of the basin. When these and the gas cease to come over, separate the apparatus, and examine the neck whether any phosphorus adheres to its internal surface; this is to be removed by plunging it into hot water. All the phosphoric drops may be afterwards brought to unite, by heating them in a vessel of water. It is then to be preserved in stopped phials containing water.—The process recommended by Fourcroy and Vauquelin is as follows. Take a quantity of burnt bones, and reduce them to powder. Put 100 parts of this powder into a porcelain or stone-ware basin, and dilute it with four times its weight of water. Forty parts of sulphuric acid are then to be added in small portions, taking care to stir the mixture after the addition of each portion. A violent effervescence takes place, and a great quantity of air is disengaged. Let the mixture remain for twenty-four hours, stirring it occasionally, to expose every part of the powder to the action of the acid. The burnt bones consist of the phosphoric acid and lime; but the sulphuric acid has a greater affinity for the lime than the phosphoric acid. The action of the sulphuric acid uniting with the lime, and the separation of the phosphoric acid, occasion the effervescence. The sulphuric acid and the lime combine together, being insoluble, and fall to the bottom. Now pour the whole mixture on a cloth filter, so that the liquid part, which is to be received in a porcelain vessel, may pass through. A white powder, which is the insoluble sulphate of lime, remains on the filter. After this has been repeatedly washed with water, it may be thrown away; but the water is to be added to that part of the liquid which passed through the filter. Take a solution of acetate of lead in water, and pour it gradually into the liquid in the porcelain basin. A white powder falls to the bottom, and the acetate of lead must be added so long as any precipitation takes place. The whole is again to be poured upon a filter, and the white powder which remains is to be well washed and dried. The dried powder is then to be mixed with one-sixth of its weight of charcoal powder. Put this mixture into an earthenware retort, and place it in a sand-bath, with the beak plunged into a vessel of water. Apply heat, and let it be gradually increased till the re-

tort becomes red hot. As the heat increases, air-bubbles rush in abundance through the beak of the retort, some of which are inflamed when they come in contact with the air at the surface of the water. A substance at last drops out similar to melted wax, which congeals under the water. This is phosphorus. To have it quite pure, melt it in warm water, and strain it several times through a piece of shamoy leather under the surface of the water. To mould it into sticks, take a glass funnel with a long tube, which must be stopped with a cork. Fill it with water, and put the phosphorus into it. Immerse the funnel in boiling water, and when the phosphorus is melted, and flows into the tube of the funnel, plunge it into cold water; and when the phosphorus has become solid, remove the cork, and push the phosphorus from the mould with a piece of wood. Thus prepared, it must be preserved in close vessels containing pure water. When phosphorus is perfectly pure, it is semi-transparent, and has the consistence of wax. It is so soft that it may be cut with a knife. Its specific gravity is from 1·77 to 2·03. It has an acrid and disagreeable taste, and a peculiar smell, somewhat resembling garlic. When a stick of phosphorus is broken, it exhibits some appearance of crystallization. The crystals are needle-shaped, or long octahedrons; but to obtain them in their most perfect state, the surface of the phosphorus, just when it becomes solid, should be pierced, that the internal liquid phosphorus may flow out, and leave a cavity for their formation. When phosphorus is exposed to the light, it becomes of a reddish colour, which appears to be an incipient combustion. It is therefore necessary to preserve it in a dark place. At the temperature of 99 deg. it becomes liquid, and if air be entirely excluded, it evaporates at 219 deg. and boils at 554 deg. At the temperature of 43 or 44 deg. it gives out a white smoke and is luminous in the dark. This is a slow combustion of the phosphorus, which becomes more rapid as the temperature is raised. When phosphorus is heated to the temperature of 148 deg. it takes fire, burns with a bright flame, and gives out a great quantity of white smoke. Phosphorus enters into combination with oxygen, nitrogen, hydrogen, and carbon. Phosphorus must be kept in water, for when exposed to the air, it gradually consumes by a slow combustion, and with only a small degree of heat will inflame. When experiments are performed with it, in order that no unpleasant accident may occur, it is necessary to have a basin of water at hand, in which it may be occasionally dipped, to prevent its inflaming from the heat of the hand. Take a piece of phosphorus, and write with it on a black board, or on a slate, or on the wall. Take away the light, and the letters will be seen shining in the dark. The phosphorus, when rubbed on the wall, slate, or board, in writing the letters, had left a small part behind, and this slowly burnt away, and when the light was removed, this combustion rendered the letters visible. After the phosphorus is all burnt, the light ceases. This experiment is sometimes employed to frighten the inexperienced; but it is most blameable to do so, as most unpleasant consequences may be the result. If writing be made with phosphorus on purple paper, after the light has ceased, the traces of the letters will be of a red colour on the paper. This arises from the phosphorus attracting oxygen in the process of combustion, and forming thereby phosphoric acid, which changes the blue into red. If a bit of phosphorus be placed on unslaked lime, and a little water sprinkled on it, the heat will quickly cause the phosphorus to inflame. If a bit of phosphorus be wrapped up in paper, and then rubbed on the table, it will set the paper on fire. Friction, by raising the temperature, produces the effect. This will in some degree explain the mode in which boxes of phosphorus are employed in striking a light. The phosphorus is usually combined with lime or sulphur, and if a brimstone match be put into the box, and rubbed against the composition, it will be set on fire, and serve to light a candle, and on a cork being put into the bottle, the fire is extinguished. In some boxes the composition is such, that it is necessary to put in the match, and on drawing it out, some part adheres to it; it must then be rubbed upon a cork, when it is enflamed, and sets the match on

fire. The cork is used because, being a weak conductor of heat, it does not carry off the heat produced in friction. These boxes act much more readily in summer than in winter. If a few grains of phosphorus be rubbed in a mortar with iron filings, they immediately take fire. Put a little bit of phosphorus into a phial, and pour on boiling water; shake the phial in the dark, and there will be an appearance of brilliant stars. Put a bit of phosphorus into a retort, with water, and boil it over a candle or lamp, and then shake it in the dark, and it will exhibit a beautiful luminous appearance, not unlike the aurora borealis. Phosphorated hydrogen gas has this property, that it inflames immediately on coming in contact with the atmospheric air. It may be made thus:—Into a retort put water, and some pieces of kali purum, or pure caustic soda, which may be got at chemists, and a piece of phosphorus; boil it over a candle or lamp, and keep the mouth of the retort under the surface of water, into a basin; then the gas will be formed, and will rise through the water, and inflame the instant it comes in contact with the air. Phosphorated lime thrown into water produces phosphorated hydrogen gas, which rises and blazes away at the surface of the water. It is supposed that the appearances called "Will with the Wisp" arises from the formation by nature of this species of gas. This gas may also be made by putting a bit of phosphorus into a glass or retort in which common hydrogen gas is made, by the solution of zinc or iron filings, in diluted sulphuric acid. Phosphorus is considered to be the cause of many natural phenomena. The light of the glow-worm, which disappears entirely when the animal is brought to the light, but which shines like a star in the hedges, in the darkness of the night, is supposed to arise from a slow phosphoric combustion. What is very extraordinary, the insect has the power of discontinuing this light at pleasure,—and which it does for its own protection from enemies. It is the female which thus shines, and, like Hero of old, guides her Leander to find his way to her abode. Fire-flies in warm climates shine from the same cause. The eyes of some animals shine in the dark with a phosphoric light. In warm weather, when the passenger looks over the stern of a ship at sea, he is surprised to see directly under her rudder, and for a short way in her wake behind her, a bright shining appearance, produced by the friction of the ship and the water, in which there is a portion of phosphorus diffused, from the decomposition of the animal bodies which perish in it. When fresh fish have been hung up, and have been kept for a week or more, a person going into the room where they are, after it is dark, will see them shining. It arises from phosphorus which is disengaged in this incipient stage of putrefaction; and were the fish kept longer, a still greater appearance of light would be perceptible. In the tropical climates, the phosphoric light in the wake of a ship is still more brilliant than with us in summer, and extends much farther behind in the wake of the vessel. There is also at times to be seen bright luminous appearances in the water; and on taking up water in a bucket, and examining it, there are found innumerable insects, from which this light proceeds. When phosphorus is combined with hydrogen gas, it is very readily inflamed. When phosphorus is heated in highly rarefied air, it forms three products: phosphoric acid; a volatile white powder, soluble in water, and which imparts its properties to it; and a red substance, which is probably an oxide of phosphorus. Phosphorus and chlorine readily combine. It combines also with iodine, in different proportions. Phosphorus combines also with sulphur. Phosphorus is soluble in oil, and makes them appear luminous in the dark. Alcohol and ether dissolve it, but more sparingly. When swallowed in the quantity of a grain, it is poisonous.

PHOSPHORUS OF BALDWIN, BOLOGNA, AND CANTON.—See *Baldwin*, *Bologna*, and *Canton*.

PHOSPHURET, the combination of phosphorus with another substance.

PHLOGISTICATED AIR. Nitrogen.

PHLOGISTICATED ALKALI. Ferroprussiate of potass.

PHRYSALITE and PYROPHYSALITE consists of alumina 57·74, silica 34·36, and fluoric acid 7·77.

PICROMEL, the characteristic principle of bile. Mix sulphuric acid and five parts of water with fresh bile, and a precipitate will be formed. Heat the precipitate, and decant the clear part, there remains a compound of sulphuric acid and picromel.

PICROTONIA, the poisonous principle of the coculus indicus, the fruit of the menispermum coculus. It unites and forms crystals with the sulphuric, nitric, muriatic, and acetic acid.

PIMELITE. A variety of steatite.

PINCHBECK. Copper, with a larger proportion of zinc than is in brass.

PINEAL CONCRETIONS, are phosphate of lime deposited in the pineal gland.

PINITE. A blackish green mineral, consisting of silica 29·5, alumina 63·75, and oxide of iron 6·75.

PISTACITE.—See *Epidole.*

PITCH.—See *Bitumen.*

PITCH-COAL.—See *Coal.*

PITCH-STONE. A species of quartz.

PIT-COAL.—See *Coal.*

PLANTS.—See *Vegetable Kingdom.*

PLASMA, consists of 96·75 silica, 0·25 alumina, iron 0·5, loss 2·5.

PLASTER OF PARIS. Sulphate of lime or gypsum is the chief constituent of the hills about Paris; and hence the name of plaster of Paris given to that mineral.

PLATINA, is one of the metals for the discovery of which we are indebted to our contemporaries. Its ore has recently been found to contain, likewise, four new metals,—palladium, iridium, osmium, and rhodium; which see; beside iron and chromium. The crude platina is to be dissolved in nitro-muriatic acid, precipitated by muriate of ammonia, and exposed to a very violent heat. Then the acid and alkali are expelled, and the metal reduced in an agglutinated state, which is rendered more compact by pressure while red hot. Pure or refined platina is by much the heaviest body in nature. Its specific gravity is 21·5. It is very malleable, though considerably harder than either gold or silver; and it hardens much under the hammer. Its colour on the touchstone is not distinguishable from that of silver. Pure platina requires a very strong heat to melt it; but when urged by a white heat, its parts will adhere together by hammering. This property, which is distinguished by the name of welding, is peculiar to platina and iron, which resemble each other likewise in their infusibility. Platina is not altered by exposure to air, neither is it acted upon by the most concentrated simple acids, even when boiling, or distilled from it. The aqua regia best adapted to the solution of platina, is composed of one part of the nitric and three of the muriatic acid. The solution does not take place with rapidity. A small quantity of nitric oxide is disengaged, the colour of the fluid becoming first yellow, and afterward of a deep reddish brown, which, upon dilution with water, is found to be an intense yellow. This solution is very corrosive, and tinges animal matter of a blackish brown colour; it affords crystals by evaporation. Count Moussin Poushkin has given the following method of preparing malleable platina:—Precipitate the platina from its solution, by muriate of ammonia, and wash the precipitate with a little cold water. Reduce it, in a convenient crucible, to the well-known spongy metallic texture, which wash two or three times with boiling water, to carry off any portion of saline matter that may have escaped the action of the fire. Boil it for about half an hour, in as much water mixed with one-tenth part of muriatic acid, as will cover the mass to the depth of about half an inch, in a convenient glass vessel. This will carry off any quantity of iron that might still exist in the metal. Decant the acid water, and edulcorate, or strongly ignite the platina. To one part of this metal take two parts of mercury, and amalgamate in a glass or porphyry mortar. This amalgamation takes place very readily. The proper method of conducting it is to take about two drachms of mercury to three drachms of platina, and amalgamate them together; and to this amalgam may be added alternate small quantities of platina and mercury, till the whole of the two metals is combined. Several pounds may be thus amalgamated in a few hours, and in the large way a proper mill might shorten the operation. As soon as the amalgam of mercury is

made, compress it in tubes of wood, by the pressure of an iron screw upon a cylinder of wood adapted to the bore of the tube. This forces the superabundant mercury from the amalgam, and renders it solid. After two or three hours, burn upon the coals, or in a crucible lined with charcoal, the sheath in which the amalgam is contained, and urge the fire to a white heat; after which the platina may be taken out in a very solid state, fit to be forged. Muriate of tin is so delicate a test of platina, that a single drop of the recent solution of tin in muriatic acid, gives a bright red colour to a solution of muriate of platina, scarcely distinguishable from water If the muriatic solution of platina be agitated with ether, the ether will become impregnated with the metal. This ethereal solution is of a fine pale yellow, does not stain the skin, and is precipitable by ammonia. If the nitro-muriatic solution of platina be precipitated by lime, and the precipitate digested in sulphuric acid, a sulphate of platina will be formed. A subnitrate may be formed in the same manner. According to M. Chenevix, the insoluble sulphate contains 54·5 oxide of platana, and 45·5 acid and water; the [illegible] of oxide, and the subnitrate 89 of oxide; but the purity of the oxide of platina in these is uncertain. Platina does not combine with sulphur directly, but is soluble by the alkaline sulphurets, and precipitated from its nitro-muriatic solution, by sulphuretted hydrogen. Pelletier united it with phosphorus, by projecting small bits of phosphorus on the metal heated to redness in a crucible, or exposing to a strong heat four parts each of platina and concrete phosphoric acid with one of charcoal powder. The phosphuret of platina is of a silvery white, very brittle, and hard enough to strike fire with steel It is more fusible than the metal itself, and a strong heat expels the phosphorus, whence Pelletier attempted to obtain pure platina in this way. He found, however, that the last portions of phosphorus were expelled with too much difficulty. Platina unites with most other metals. Added in the proportion of one-twelfth to gold, it forms a yellowish-white metal, highly ductile, and tolerably elastic, so that Mr Hatchett supposed it might be used with advantage for watch-springs and other purposes. Its specific gravity was 19·013. Platina renders silver more hard, but its colour more dull. Copper is much improved by alloying with platina. From 1-6th to 1-25th, or even less, renders it of a golden colour, *harder*, susceptible of a finer polish, smooth-grained, and much less liable to rust. Alloys of platina with tin and lead are very apt to tarnish.—See *Iron.* From its hardness, infusibility, and difficulty of being acted upon by most agents, platina is of great value for making various chemical vessels. *Platinum* may be drawn into very fine wire. There are two oxides of platinum. It is dissolved in chlorine, and sulphate of platinum may be obtained by passing a current of sulphuretted hydrogen gas through the nitro-muriatic solution. A fulminating powder is obtained from platinum

PLEONAST.—See *Ceylanite.*

PLUMBAGO. The present state of chemical science is very embarrassing to all those who are not particularly conversant with the daily discoveries which are making. When the student has acquired a knowledge of the principal facts and the usually re[illegible]d theories, in the course of a few months he takes up a scientific journal, and he finds some important discovery, a new theory, and that what he had learned and endeavoured to keep in mind, he must now unlearn and forget. This observation will apply to plumbago or black lead, which was usually considered a combination of carbon and iron; but it is now asserted that the presence of iron [illegible] merely adventitious, and that plumbago is nothing more than an oxide of carbon. It is worthy of notice, that plumbago is often found in considerable abundance in cast iron, as in cannon; and it is remarkable, that the weakest guns are by no means those which have the greatest abundance of it. The best malleable iron contains none of it, and a great part of the process of refining consists in the combustion of this substance; and hence, in some degree, the loss of weight. The pig metal used for shells, which is of various qualities, generally distinguished into three kinds, white, grey, and black, afford black lead after solution, but various in dif-

ferent specimens. The blackest pig-metal, by solution in acids, of which the acetous is the best, yields the greatest quantity of black lead, and in the most solid state. It is sometimes equal to the iron in bulk, and so solid that it may be cut with a knife into pencils. Black lead thus obtained becomes hot on exposure to the air, smoking whilst there is any moisture to be evaporated, particularly when the surfaces are scraped off in succession, so as to give access to the air. This arises from the absorption of oxygen. In those cases where the substance does not heat on being taken out of the fluid, it arises from the process of oxygenation having been performed during the solution. The iron cones in the porter-backs, after being corroded by the porter, and taken out and scraped, have been found to contain nothing but black lead, the iron having been dissolved; and this black lead, when it has been scraped, has been found to be very hot, and to cause evaporation of the moisture put upon it. The guns taken by means of diving-bells out of the vessel of the Spanish Armada, which was sunk in Mull Sound in 1588, by some adventurers in 1744, were found to be corroded, and when scraped felt very hot, to the astonishment of the Highlanders, who could not conceive the cause, after the guns had been nearly two centuries in the sea. Black lead may thus be made in an artificial way, and found to be the same substance as that formed by nature.—See *Black Lead.*

POISONS, substances which, when applied to living bodies, tend to derange the vital functions, and produce death. Some poisons act by their corrosive property and corrosive sublimate; other poisons by being most powerfully astringent; some poisons are acrid, others narcotic and stupifying, which probably have a direct power upon the brain; some destroy animal life by their putrescent qualities.

POLYCHROITE, the colouring matter of saffron.

POMPHOLIX, white oxide of zinc.

PONDEROUS SPAR.—See *Heavy Spar.*

PORCELAIN EARTH.—See *Clay.*

PORCELAIN, is the most beautiful and the finest of all earthen wares. The art of making porcelain is one of those in which Europe has been excelled by oriental nations. The first porcelain that was seen in Europe was brought from Japan and China. The whiteness, transparency, fineness, neatness, elegance, and even magnificence of this pottery, which soon became the ornament of sumptuous tables, did not fail to excite the admiration and industry of Europeans. Father Entrecolles, missionary at China, sent home a summary description of the process by which the inhabitants of that country make their porcelain, and also a small quantity of the materials which they employ in its composition. He said that the Chinese composed their porcelain of two ingredients, one of which is a hard stone or rock, called by them petuntse, which they carefully grind to a very fine powder, and the other, called by them kaolin, is a white earthy substance, which they mix intimately with the ground petuntse. Reaumur examined both these matters, and having exposed them separately to a violent fire, he discovered that the petuntse had fused without addition, and that the kaolin had given no sign of fusibility. He afterwards mixed these matters, and formed cakes of them, which, by baking, were verted into porcelain similar to that of China.

PORCELAIN OF REAUMUR. Reaumur gave the quality of porcelain to glass; that is, he rendered glass of a milky colour, semi-transparent, so hard as to strike fire with steel, infusible, and of a fibrous grain, by means of cementation. The process which he published is not difficult. Common glass, such as that of which wine bottles are made, succeeds best. The glass vessel which is to be converted into porcelain, is to be inclosed in a baked earthen case or seggar. The vessel and case are to be filled with a cement composed of equal parts of sand and powdered gypsum or plaster, and the whole is to be put into a potter's kiln, and to remain there during the baking of common earthenware; after which the glass vessel will be found transformed into such a matter as has been described.

PORPHYRY, derives its name from the Greek word signifying red,

as the porphyry used by the ancients was most frequently of that colour. The term porphyry is very vague, being applied to all rocks that have a compact base or ground in which crystals of any kind are imbedded and distinctly visible. Thus, according to the kind of stone in which the crystals occur, the porphyry takes its more appropriate name, as horn-stone porphyry, clay-stone porphyry, pitch-stone and obsidian porphyry, &c. The base of porphyry is generally allied to trap, and is fusible. The crystals are either quartz or felspar, but more commonly the latter, forming four-sided or six-sided prisms, whose length is greater than the breadth.

PORTLAND. A compact sand stone from the isle of Portland united by a calcareous cement.

POTASS. This alkali is commonly called the vegetable alkali, because it is obtained from the ashes of vegetables. It has been discovered by Sir H. Davy to consist of a metal which he calls potassium and two portions of oxygen and water. In the fashionable nomenclature of the day it is called the hydrated deutoxide of potassium. In the arts of life, and inde

tions, we are little concerned with potassium, but with this very commonly and useful alkali in the state in which we find it.

Table of the saline product of one thousand lbs. of ashes of the following vegetables:—

	Saline products.
Stalks of Turkey wheat or mais,	198 lbs.
Stalks of sunflower,	349
Vine-branches	1[illegible]6
Elm - -	166
Box - - -	[illegible]
Sallow - -	102
Oak - - -	111
Aspen - -	61
Beech - -	219
Fir - - -	132
Fern cut in August,	116 or 125 according to Wildenheim.
Wormwood	748
Fumitory - -	360
Heath - -	115 Wildenheim.

On these tables Kirwan makes the following remarks:—

1. That in general weeds yield more ashes, and their ashes much more salt than woods; and that consequently as to salts of the vegetable alkali kind, as potash, pearlash, cashup, &c. neither America, Trieste, nor the northern countries, have any advantage over Ireland.

2. That of all weeds fumitory produces most salt, and next to it wormwood. But if we attend only to the quantity of salt in a given weight of ashes, the ashes of wormwood contain most. Trifolium fibrinum also produces more ashes and salt than fern.

The process for obtaining pot and pearlash is given by Kirwan, as follows:—

1 The weeds should be cut just before they seed, then spread, well dried, and gathered clean.

2. They should be burned within doors on a grate, and the ashes laid in a chest as fast as they are produced. If any charcoal be visible, it should be picked out, and thrown back into the fire. If the weeds be moist, much coal will be required. A close smothered fire, which has been recommended by some, is very prejudicial.

3 They should be lixiviated with 'elve times their weight of boiling water. A drop of the solution of corrosive sublimate will immediately dis- when the water ceases to take up any more alkali. The earthy matter that remains is said to be a good manure for clayey soils.

4. The ley thus formed should be evaporated to dryness in iron pans. Two or three at least of these should be used, and the ley, as fast as it is concreted, passed from the one to the other. Thus, much time is saved, as weak leys evaporate more quickly than the stronger. The salt thus procured is of a dark colour, and contains much extractive matter, and being formed in iron pots, is called potash.

5. This salt should then be carried to a reverberatory furnace, in which the extractive matter is burnt off, and much of the water dissipated: hence it generally loses from ten to fifteen per cent. of its weight. Particular care should be taken to prevent its melting, as the extractive matter would not then be perfectly consumed, and the alkali would form such a union with the earthy parts as could

not easily be dissolved. Kirwan adds this caution, because Dr. Lewis and Mr. Dossie have inadvertently directed the contrary. This salt thus refined is called pearlash, and must be the same as the Dantzic pearlash.

To obtain this alkali pure, Berthollet recommends, to evaporate a solution of potash, made caustic by boiling with quicklime, till it becomes of a thickish consistence, to add about an equal weight of alcohol, and let the mixture stand some time in a close vessel. Some solid matter, partly crystallized, will collect at the bottom; above this will be a small quantity of a dark-coloured fluid; and on the top another lighter. The latter separated by decantation, is to be evaporated quickly in a silver basin in a sand heat. Glass, or almost any other metal, would be corroded by the potash. Before the evaporation has been carried far, the solution is to be removed from the fire, and suffered to stand at rest; when it will again separate into two fluids. The lighter, being poured off, is again to be evaporated with a quick heat; and on standing a day or two in a close vessel, it will deposit transparent crystals of pure potash. If the liquor be evaporated to a pellicle, the potash will concrete without regular crystallization. In both cases a high coloured liquor is separated, which is to be poured off; and the potash must be kept carefully secluded from air. A perfectly pure solution of potash will remain transparent, on the addition of lime-water, show no effervescence with dilute sulphuric acid, and not give any precipitate on blowing air from the lungs through it by means of a tube. To obtain very pure potass for the purpose of experiments, ignite potass in a crucible, dissolve the residue in water, filter, boil in quicklime, and after the quicklime has fallen to the bottom, decant the clear liquor, and evaporate the water. This will be water and potass, called in the fashionable nomenclature, hydrate of potass; it is very caustic, changes the purples of violet and cabbage to green, and yellow turmeric to a reddish brown. It has a strong attraction for water and will readily melt if exposed to the air, becoming what was formerly called oil of tartar. About 100 parts of pure potass are equivalent to 70 of concentrated sulphuric acid; therefore a good alkalimeter may be made by having a graduated tube, which divided into 100 equal parts, let 70 be filled with acid and the rest with pure water. If the alkali be quite pure it will require the whole liquid in the tube to saturate 100 of the alkali; but if less will be sufficient, such as 75 parts, then we know that there are only 75 per cent. pure alkali; and so on for any other proportion.

POTASSIUM, is the metallic basis of potass, and may be obtained by placing hydrate of potass between two discs of platinum connected with the extremities of a powerful voltaic apparatus, when it will undergo fusion, and the oxygen will be separated and the metallic globules will appear at the negative surface. It may also be obtained by melting potass slowly in a gun-barrel, in contact with iron turnings heated to whiteness, the air being excluded. It has also been got by igniting potass with charcoal. Potassium is lighter than water; its specific gravity being 0·865 At common temperature it is soft and easily moulded by the fingers; at 150 it fuses, and in a heat a little below redness it rises in vapour. When newly cut it is splendent like silver, but soon tarnishes in the air, on which account it must be kept in a phial in pure naphtha. When thrown into the water it swims on the surface burning with a beautiful red mixed with violet. It combines with oxygen in different proportions. It has the strongest attraction for oxygen, on which account it has been successfully employed by sir H. Davy and other chemists, in decomposing substances which could not be acted on by any other way. Potassium combines with chlorine, hydrogen, sulphur, phosphorus, charcoal, and iodine.

POTATOES. The potatoe is the bulb that contains the largest quantity of soluble matter in its cells and vessels; and it is of most importance in its application as food. Potatoes in general afford from one-fifth to one-seventh their weight of dry starch. From 100 parts of the common kidney potatoe, Dr. Pearson obtained from 32 to 28 parts of meal, which contained from 23 to 20 of starch and

mucilage: and 100 parts of the apple potatoe in various experiments, afforded me from 18 to 20 parts of pure starch. From five pounds of the variety of the potatoe called captain hart, Mr. Skrimshire, jun. obtained 12 oz. of starch, from the same quantity of the rough red potatoe 10½ oz., from the moulton white 11¾, from the Yorkshire kidney 10¾ oz., from hundred eyes 9 oz., from purple red 8¼, from ox noble 8¼. The other soluble substances in the potatoe are albumen and mucilage. From the analysis of Einhoff it appears 7680 parts of potatoes afford

Of starch	1153
— Fibrous matter analogous to starch	540
— Albumen	107
— Mucilage in the state of a saturated solution	312
	2112

So that a fourth part of the weight of the potatoe at least may be considered as nutritive matter.

POTTERY. The art of making pottery, is intimately connected with chemistry, not only from the great use made of earthen vessels by chemists, but also because all the processes of this art, and the means of perfecting it, are dependent on chemistry. The process of manufacturing stoneware, according to Dr. Watson, is as follows:—Tobacco-pipe clay from Dorsetshire is beaten much in water. By this process, the finer parts of the clay remained suspended in the water, while the coarser sand and other impurities fall to the bottom. The thick liquid, consisting of water and the finer parts of the clay, is farther purified by passing it through hair and lawn sieves, of different degrees of fineness. After this, the liquid is mixed (in various proportions for various wares) with another liquor, of as nearly as may be the same density, and consisting of flints calcined, ground, and suspended in water. The mixture is then dried in a kiln; and being afterward beaten to a proper temper, it becomes fit for being formed at the wheel into dishes, plates, bowls, &c. When this ware is to be put into the furnace to be baked, the several pieces of it are placed in the cases made of clay, called seggars, which are piled one upon another, in the dome of the furnace. A fire is then lighted; and when the ware is brought to a proper temper, which happens in about forty-eight hours, it is glazed by common salt. The salt is thrown into the furnace, through holes in the upper part of it, by the heat of which, it is instantly converted into a thick vapour; which, circulating through the furnace, enters the seggar through holes made in its side, (the top being covered to prevent the salt from falling on the ware); and attaching itself to the surface of the ware, it forms that vitreous coat upon the surface which is called its glaze. The yellow or queen's-ware is made of the same materials as the flint-ware; but the proportion in which the materials are mixed is not the same, nor is the ware glazed in the same way. The flint-ware is generally made of four measures of liquid flint, and of 18 of liquid clay. The yellow ware has a greater proportion of clay in it. In some manufactories they mix 20, and in others 24 measures of clay, with four of flint. These proportions, if estimated by the weight of the materials, would probably give for the flint-ware about 3 cwt. of clay to 1 cwt. of flint, and for the yellow ware somewhat more clay. The proportions, however, for both sorts of ware, depends very much upon the nature of the clay, which is very variable even in the same pit. Hence a previous trial must be made of the quality of the clay, by burning a kiln of the ware. If there be too much flint mixed with the clay, the ware, when exposed to the air after burning, is apt to crack; and if there be too little, the ware will not receive the proper glaze from the circulation of the salt vapour. This glaze, even when it is most perfect, is in appearance less beautiful than the glaze on the yellow ware. The yellow glaze is made by mixing together, in water, till it becomes as thick as cream, 112 lb. of white lead, 24 lb. of ground flint, and 6 lb. of ground flint-glass. Some manufactories leave out the glass, and mix only 80 lb. of white lead with 20 lb. of ground flint; and others doubtless observe different rules, of which it is very difficult to obtain an account. The ware before it is glazed is baked in the fire. By this means it acquires the property of strongly im-

bibing moisture. It is therefore dipped in the liquid glaze, and suddenly taken out: the glaze is imbibed into its pores, and the ware presently becomes dry. It is then exposed a second time to the fire, by which means the glaze it has imbibed is melted, and a thin glassy coat is formed upon its surface. The colour of this coat is more or less yellow, according as a greater or less proportion of lead has been used. The lead is prinsipally instrumental in producing the glaze, as well as in giving it the yellow colour; for lead, of all the substances hitherto known, has the greatest power of promoting the vitrification of the substances with which it is mixed. The flint serves to give a consistence to the lead during the time of its vitrification, and to hinder it from becoming too fluid, and running down the sides of the ware, and thereby leaving them unglazed. The yellowish colour which lead gives when vitrified with flints, may be wholly changed by very small additions of other mineral substances. Thus, to give one instance, the beautiful black glaze, which is fixed on one sort of the ware made at Nottingham, is composed of 21 parts by weight of white lead, of five of powdered flints, and three of manganese. The queen's-ware, at present, much whiter than formerly. The coarse stone ware made at Bristol, consists of tobacco-pipe clay and sand, and is glazed by the vapour of salt, like Staffordshire flint-ware; but it is far inferior to it in beauty.

POTENTIAL CAUTERY. This name has been given by surgeons to a powerful caustic of pure potash.

POTSTONE. See *Ollaris Lapis*.

POWDER OF ALGAROTH. The white oxide of antimony, precipitated from the muriate by water.

PRASE. A leek green mineral consisting of 98·5 silica, alumina and magnesia 0·5, and oxide of iron 1.

PRECIPITANTS. Such bodies as put into a solution will cause precipitation.

PRECIPITATE. When a body dissolved in a fluid, is either in whole, or in part made to separate and fall down in the concrete state, this falling down is called precipitation, and the matter thus separated is called a precipitate.

PRECIPITATE, *per se.* Red oxide of mercury, by heat.

PREHNITE. There are kinds of this mineral, the foliated and the fibrous. The constituents of the first kind, according to Klaproth, are, silica 43·83, alumina 30·33, lime 18·33, oxide of iron 5·66, water 1·83. The constituents of the fibrous prehnite are nearly the same, and the difference is in the arrangement.

PRIMARY ROCKS, are so called by the Wernerians, because therein no organic remains have been found hence it is supposed they were formed prior to the creation of animals or vegetables. They are extremely hard, and their substances are pure crystallized matter, in large vertical masses, more or less inclined to the horizon, and without fragments of other rocks. They form the lowest part of the earth's surface with which we are acquainted; and not only constitute the foundation on which the other rocks rest, but in many situations pierce through the incumbent rocks and strata, and form the highest mountains in alpine districts. We must not conclude, on seeing a range of mountains bounded by a plain, that they terminate at their apparent basis. On the contrary, they dip under the surface at angles more or less inclined, stretching below the lower grounds and lesser hills, and often rise again in remote districts. We may, with apparent probability, infer that their formation was prior to the existence of animals or vegetables on our planet in its present state, because the intermediate rocks contain the organic remains of zoophytes, or those animals considered as forming the first link in the chain of animated beings.

PROSTATE CONCRETIONS.—Phosphate of lime forming calculi in the prostate gland.

PRUSSIAN ALKALI. See *Prussic Acid*.

PRUSSIAN BLUE. A most valuable blue pigment obtained from a combination of prussic acid and iron.

PRUSSIC ACID. The combination of this acid with iron was long known and used as a pigment by the name of Prussian blue, before its nature was understood. Macquer first found, that alkalis would decompose Prussian blue, by separating the iron

from the principle, with which it was combined in it, and which he supposed to be phlogiston. In consequence, the prussiate of potash was long called phlogisticated alkali. Bergmann, however, from a more scientific consideration of its properties, ranked it among the acids; and as early as 1772, Sage announced, that this animal acid, as he called it, formed with the alkalis neutral salts, that with potash forming octaëdral crystals, and that with soda rhomboids or hexagonal laminæ. About the same time Scheele instituted a series of sagacious experiments, not only to obtain the acid separate, which he effected, but also to ascertain its constituent principles. These, according to him, are ammonia and carbon; and Berthollet thereafter added, that its triple base consists of hydrogen and azote, nearly, if not precisely, in the proportions that form ammonia and carbon. Berthollet could find no oxygen in any of his experiments for decomposing this acid. Scheele's method is this: Mix four ounces of prussian blue with two of red oxide of mercury prepared by nitric acid, and boil them in twelve ounces by weight of water till the whole becomes colourless; filter the liquor, and add to it one ounce of clean iron filings, and six or seven drachms of sulphuric acid. Draw off by distillation about a fourth of the liquor, which will be prussic acid; though, as it is liable to be contaminated with a portion of sulphuric, to render it pure, it may be rectified by re-distilling it from carbonate of lime. This prussic acid has a strong smell of peach blossoms, or bitter almonds; its taste is at first sweetish, then acrid, hot, and virulent, and excites coughing; it has a strong tendency to assume the form of gas; it has been decomposed in a high temperature, and by the contact of light, into carbonic acid, ammonia, and carburetted hydrogen. It does not completely neutralize alkalis, and is displaced even by the carbonic acid; it has no action upon metals, but unites with their oxides, and forms salts for the most part insoluble; it likewise unites into triple salts with these oxides and alkalis; the oxygenated muriatic acid decomposes it. The peculiar smell of the prussic acid could scarcely fail to suggest its affinity with the deleterious principle that rises in the distillation of the leaves of the lauro-cerasus, bitter kernels of fruits, and some other vegetable productions; and M. Schrader of Berlin has ascertained the fact, that these vegetable substances do contain a principle capable of forming a blue precipitate with iron; and that with lime they afford a test of the presence of iron, equal to the prussiate of that earth. Dr. Buchols of Weimar, and Mr. Roloff of Magdeburg, confirm this fact. The prussic acid appears to come over in the distilled oil. M. G. Lussac and M. Vauquelin have investigated the nature and combinations of prussic acid. Vauquelin's process of making it is as follows:—Into a solution consisting of two ounces of cyanuret of mercury and sixteen ounces of water pass as much sulphuretted hydrogen gas as will serve to decompose the salt, leaving an excess of the gas. Filter the liquor to separate the sulphuret of mercury formed, and treat the filtered liquor with an excess of the subcarbonate of lead. Shake the bottle until the excess of sulphuretted hydrogen be absorbed. Filter once more, and the remaining liquor will be diluted hydrocyanic acid, of a proper strength for medical purposes. Dr. Granville recommends Scheele's process and Vauquelin's process as perfectly good for the purpose of medical practice. The prussic acid is not found ready formed in the blood. The blood contains, indeed, the principles of the prussic acid, but they require the presence of an alkali to influence that peculiar attraction and combination of their molecules, which constitutes this acid. If the residue of animal matter be washed in water no prussic acid is found, unless alkalies be present; but on treating animal matter by heat, ammonia is formed, which promotes the subsequent formation of prussic acid. The following are the properties of the prussic acid. It is capable of assuming a gaseous form, and may be collected in that state over mercury by heating in a retort the crystallized ferro-prussiate of potash with diluted sulphuric acid. This is absorbed by alcohol, and forms a permanent combination with it; but its solution in water undergoes spontaneous decomposition, becomes

yellow in a few months and deposits charcoal. The gas has also a constant tendency to escape from its watery solution. The gas of prussic acid is highly inflammable, and by contact with chlorine gas, is instantly decomposed. A new compound is formed, which has been called by Gay Lussac the chloro-cyanic acid. It appears to be one volume of vapour of charcoal, half a volume of azote, and half a volume of chlorine condensed into one volume. This gas received into the lungs of small animals, is speedily fatal; and its watery solution when taken into the stomachs is equally fatal. In its pure state it becomes liquid at ordinary temperatures. If prussic acid gas be disengaged from prussiate of mercury by muriatic acid, and be made to pass through two bottles containing dry muriate of lime and chalk, it may be condensed in a third which is surrounded by a freezing mixture. Liquid prussic acid thus obtained, is a limpid and colourless fluid. Its taste is at first cool, but soon becomes hot and acrid. It reddens litmus paper slightly. It is highly volatile and boils at 79 deg. Fahrenheit, at 68 deg. it supports a column of mercury at very nearly 15 inches; and it increases five-fold any gas with which it is mixed. It congeals at the temperature produced by the mixture of snow and salt, and liquefies at 5 deg. Fahrenheit. A drop of it placed upon paper becomes solid instantly, because the cold produced by the evaporation of one portion, reduces the temperature of the remainder below its freezing point. The sp. gr. of prussic acid vapour is to that of common acid as 0·9476 to 1; but by calculations founded on the composition and condensation of its elements, it may be stated at 0·9360. At a temperature between 86 deg. and 95 min. it forms with oxygen gas a mixture which detonates with the electric spark. The component parts by volume have already been stated; by weight they appear to be as follows:

Carbon,	44·39
Azote,	51·71
Hydrogen	3·90

It is remarkable when compared with other animal products for the great quantity of azote which it contains, and the small quantity of hydrogen. This acid has been decomposed when kept in a close vessel in less than an hour, but it has occasionally been kept 15 days without alteration. Prussic acid owes its acidifying powers to hydrogen: and its base consisting of carbon and azote, should be called prussine, but it has also been denominated by Gay Lussac, cyano-gen, as it generates blue colour; and from the great merits of that chemist, his nomenclature has prevailed, and the prussic acid has also been called hydrocyanic. Prussic acid does not appear to have a strong affinity for alkalies; nor does it take them from carbonic acid; for no effervescence arises on adding it to a solution of alkaline carbonates. Its combinations with alkalies and earths are decomposed by exposure to carbonic acid gas, even when highly diluted in atmospheric air. It readily combines with pure alkalies and forms crystallizable salts, which have an excess of alkali, and are soluble in alcohol; and incapable of forming Prussian blue with salts containing the peroxide of iron. Prussine combines with barytes, potash, and soda, forming true prussides of these alkaline oxides, which are analogous to what are called oxymuriates of lime, potash, and soda. Society is under the highest obligation to Dr. Granville for pointing out the benefits to be derived by the judicious use of prussic acid in relieving some of the severest diseases which afflict human nature. For this purpose it must be diluted with water. It had been observed that when this acid was administered to dogs they lost all trace of sensibility and muscular contraction, whilst they continued to breathe, and the action of the blood went on apparently unaltered for hours after. It was hence inferred, that with proper caution it might prove highly advantageous in cases of excessive sensibility and irritation. This has happily been proved by experience. In cases of spasmodic coughs, asthmas, and hooping coughs, the prussic acid has had good effects. In cases of high pulmonary and other inflammations, the violence of the disease has been quickly subdued without having recourse to bleeding. This is an incalculable advantage in cases where, on account of the age, debility, and

depletion of the patient, the lancet cannot with safety be used. Dr. Granville considers prussic acid as the best palliative in cases of confirmed tubercular consumption. That it checks the progress of pulmonary consumption when in its incipient state. That in cases of asthma, chronic catarrhs, and coughs of long standing, it has proved more beneficial than any other medicine. That in dry spasmodic coughs, and more especially in hooping cough, it has been used with constant and complete success. That it may be employed as a powerful sedative where other narcotics cannot relieve high spasmodic action, excess, irritability, and acute pain. A series of experiments were lately undertaken by a company of associated physicians, surgeons, and naturalists at Florence, for the purpose of ascertaining the best state of the hydrocyanic or prussic acid for medicinal purposes. Their joint opinions is thus expressed:—"We may then conclude from our researches that the essential oil of the prunus lauro-cerausus is to be preferred in medical practice to all other preparations which contain the hydrocyanic acid; for, unlike the distilled water of the plant and pure prussic acid, it contains the same proportion of the acid, and is of the same power, whether recently prepared, or old, when made in one place or another, after exposure to the air, to light, or to heat. We think, also, that the oil of cloves or almonds is the most proper vehicle in the proportion of an ounce to the drops of the essence, or in a smaller dose when employed by friction externally." The chloro-prussic, or as it is called by Gay Lussac, the chloro-cyanic acid, is a combination of the prussic acid with chlorine, which then acquires new properties. Its odour is increased, and it no longer affords prussian blue with solutions of iron, but a green precipitate, which becomes blue by the addition of sulphurous acid. It was formerly supposed, that the prussic acid had acquired, when thus altered, a quantity of oxygen, and it was accordingly called oxy-prussic acid, but Gay Lussac ascertained that it consisted of equal volumes of chlorine and cyanogen, and accordingly it has been properly called chloro-cyanic, or chloro-prussic acid. The aqueous mixture of chloro-prussic and carbonic acids is colourless, of a very strong smell, reddens litmus, is not inflammable, and does not detonate when mixed with twice its bulk of oxygen and hydrogen. With potassium the chloro-cyanic acid exhibits the same phenomena as cyanogen. The inflammation is quite as slow, and there is an equal diminution of the volume of gas. Ferro-prussic acid may be made from the salt called prussiate of potash, by pouring into its solution, so long as any precipitate falls, the hydrosulphuret of barytes; then throwing the whole on a filter, and washing the precipitate with cold water. It is then to be dried, and 100 parts being dissolved in cold water, 30 of concentrated sulphuric acid are to be added, and the mixture is to be agitated and set aside to repose. The supernatant liquor is ferro-prussic acid. It is without smell, of a yellow lemon colour; and readily decomposed by light and heat. By the decomposition hydrocyanic acid is formed and white ferro-prussiate of iron, which soon becomes blue. It will readily displace acetic acid from the acetates, and form ferro-prussiates. There are some chemists who suppose that this acid is merely a hydrocyanate or prussiate of iron, which from the mutability of its constituent parts, is easily decomposable by light and heat. This acid was called by Mr. Porrett ferruretted chyacic acid. The ferro-prussiate of potass is a beautiful salt manufactured on a large scale in several parts of Great Britain, as the first step towards the manufacture of prussian-blue, chiefly from horns and hoofs of animals. They are put into iron vessels along with good pearl-ash, calcined to a sort of paste, being constantly stirred during the process; the paste is thrown, when hot, into water, and by evaporating the water which is drawn off, after it has become cool and clear, the salts are obtained. By redissolving and again evaporating, finer crystals are obtained, which are transparent, and of a beautiful lemon or topaz colour, of specific gravity 1·830: it is decomposed by all the salts of the permanent metals. It may be obtained by acting on prussian blue with pure potash. Ferro-prussiate of soda may

also be obtained from prussian blue, by pure soda, and the salts are of a yellow transparent colour with a bitter taste. The ferro-prussiate of lime is formed from prussian-blue and lime water, and evaporating the solution. Ferro prussiate of barytes may be formed in the same way. The ferro-prussiate of strontian and magnesia may also be made. In order to form *prussian-blue*, the first step is the making of ferro-prussiate of potass: one part of this salt is to be mixed with one part of sulphate of iron, and four parts, or more, of alum; the whole of these salts being previously dissolved in water, prussian blue, which consists of deuto-ferro prussiate of iron, is precipitated with a greater or less portion of alumina, and is afterwards to be dried on chalk stones in a stove. Prussian blue is considerably denser than water, without taste or smell, and is of a very deep blue colour. It is not acted upon by either water or alcohol; it may be decomposed in boiling solutions of potash, soda, lime, barytes and strontites, when there will be formed ferro-prussiates of these bases, and a residue of a yellowish brown sub ferro prussiate of iron. Aqueous chlorine changes the blue to a green in a few minutes, if the blue be recently precipitated. By means of aqueous sulphuretted hydrogen, the blue ferro-prussiate is reduced to the white proto-ferro prussiate. The sulphuro-prussic acid is a combination of sulphur and cyanogen.

PULMONARY CONCRETIONS. These consist of carbonate of lime united by a membraneous or animal matter, forming in the cavities of the lungs.

PUMICE STONE. The light-coloured or whitish porous lavas become fibrous, and pass into a light spongy stone called pumice. The island of Lipari contains a mountain entirely formed of white pumice. When seen at a distance, it excites the idea that it is covered with snow from the summit to the foot. Almost all the pumice-stone employed in commerce is brought from this immense mine. The mountain is not one compact mass, but is composed of balls or globes of pumice aggregated together, but without adhesion. From hence Spalanzani infers that the pumice was thrown out of a volcano in a state of fusion, and took a globose form in the air. Some of these balls of pumice do not exceed the size of a nut, others are a foot or more in diameter. Many of these pumices are so compact that no pores or filaments are visible to the eye; when viewed with a lens, they appear like an accumulation of small flakes of ice. Though apparently compact, they swim on water. Other pumices contain pores and cavities, and are composed of shining white filaments. By a long continued heat pumice-stone melts into a vitreous semi-transparent mass, in which a number of small crystals of white felspar are seen. In all probability, pumice is formed from felspar by volcanic fires. —Immense quantities of pumice are sometimes thrown up by submarine volcanoes. It has been seen floating upon the sea over a space of three hundred miles at a great distance from any known volcano; and from hence it may be inferred that submarine volcanoes sometimes break out at such vast depths under the ocean, that none of their products reach the surface, except such as are lighter than water.

PURPURIC ACID, is obtained by digesting the excrements of the Boa Constrictor, which consist of pure lithic acid, or urinary calculi, with nitric acid, when an effervescence takes place, and the lithic acid is dissolved, forming a beautiful purple liquid. The excess of nitric acid is to be neutralised with ammonia, and the whole concentrated by slow evaporation, when the colour of the solution becomes of a deeper purple, and dark granular crystals begin to separate. These are a compound of the acid and ammonia; and the ammonia being displaced by digesting a solution of caustic potass till the red colour disappear, and the solution being gradually dropped into dilute sulphuric acid, the purpuric acid is obtained in a state of purity.—This acid principle is also obtained from the lithic acid by chlorine and iodine. It combines with the alkalis, earths, and metallic oxides. It expels carbonic acid from the alkaline carbonates, by the assistance of heat, and does not combine with any other acid; which circumstances are considered sufficient to entitle it to be

considered as a distinct acid.—Purpurate of ammonia is of a garnet red colour; and the same is the case with purpurate of potass, soda, strontian, and lime. The purpuric acid and its compounds are probably the bases of many animal and vegetable colours. The pink sediment in the urine of persons suffering from fevers, arises from the purpurate of ammonia and soda.

PUTREFACTION. The decomposition of animal and vegetable matter, accompanied with a fœtid smell. The solid and fluid parts are changed into gaseous matter and vapours, and earthy particles remain. If animal or vegetable substances be congealed by hard frost, or made very dry and hard, so that no motion of their particles can take place, putrefaction is stopped. See *Caloric*.

PYRENEITE, a mineral found in the Pyrenees, consisting of silica 43, alumina 16, lime 20, oxide of iron 16, water 4.

PYRITES, a native compound of metal, with sulphur.

PYROLIGNEOUS ACID. Pyroligneous acid, or what is generally termed vinegar of wood, is that which promises to be of most use as an animal antiseptic. From its low price it is adapted for general use; more particularly, as it not only preserves the food from putrefaction, but also gives to it that smoky and acid taste peculiar to well-dried hams and red herrings. Indeed, the only difference in using this acid, and drying by turf or wood-smoke, seems to be merely the mode of operation; for in both cases this acid is the agent employed. In one case, the animal substance is acted on during the distillation of the acid; and in the other, the already-formed acid is applied to the substance by immersion.—This acid, the product of the distillation of wood, is now well known in Britain as an article of commerce, and in its native state is a liquid of the colour of white wine, possessing a strong acid and slightly astringent taste, combined with an empyreumatic smell. When allowed to remain in a state of rest for eight or ten days, tar of a black colour subsides, and the acid is then comparatively transparent. To purify it further, it undergoes the process of distillation, by which it is freed from a still greater portion of the tar with which it is combined, and is thus rendered still more transparent. But though the process of distillation be repeated without end, it will never be freed from the volatile oil with which it is combined, and which is the cause of the empyreuma constantly attending it. In short, it contains the same properties for the preservation of animal matters from putrefaction as smoking them by wood does, which is practised at present by the most barbarous nations, and which has been handed down from the remotest ages of antiquity. The best mode of preparing Pyroligneous Acid is as follows:—place a large cast-iron cylinder, or retort (similar to those used for the production of carburetted hydrogen gas) in a furnace, so that it may receive as much heat all round as possible. One end of this cylinder must be so constructed as to open and shut, to admit wood and exclude the air. Oak, in pieces about a foot in length, is to be put into the cylinder, which is to be filled as full as possible, without being wedged, and the door must be shut close to exclude air; from the cylinder let a worm run through cold water to condense the acid; by this it is conveyed to a large cask placed on one end, where there is a pipe to carry it from that to two or three more: thus it is completely secured from flying off in the vaporous state. The fire is now to be raised to a great heat, sufficiently powerful to convert the wood completely into charcoal. When the acid ceases to come over, the fire is to be taken out, and the mass of wood left to cool in the confined state, when it becomes perfect charcoal.—In the first cask tar is chiefly contained with the acid, it precipitates to the bottom, and is drawn off by a cock; it is afterwards boiled in an iron boiler to evaporate the acid, before it is fit for use. If the acid is not strong enough, it is put into large square vats about six inches deep, for the purpose of making a large surface, to evaporate a part of the water contained in the acid more speedily by a slow heat. These vats are bedded on sand upon the top of a brick stove, where a gentle heat is applied; thus it may be procured in a pretty strong state.—Mr.

Stotze, apothecary at Halle, has discovered a method of purifying vinegar from wood, by treating it with sulphuric acid, manganese, and common salt, and afterwards distilling it over. For this method he has obtained a prize from the Royal Society of Gottingen. This gentleman has likewise verified the method proposed by professor Meineke, in 1814, of preserving meat by means of vinegar from wood, and by continued treatment with the same acid, has converted bodies into mummies.—At a recent anniversary of the Whitehaven Philosophical Society, two specimens of meat cured with the pyroligneous acid were exhibited by one of the members, which had been prepared on the 7th of September, 1819. One had been hung up at home, and the other sent out to the West Indies, to try the effect of climate upon it, and brought back on the return of the ship to that port. They were tasted by all present, and declared to be perfectly sweet, fresh, and fit for use, after a lapse of fifteen months. Besides its antiseptic use, this acid is employed instead of acetate of lead by the calico printers, to make their acetate of alumina, or iron liquor. Though not very pure, it answers sufficiently well for blacks, browns, drabs, &c.; but for yellows and reds, it is not so good, owing to the oil and tartar, which is in combination with it.

PYROLITHIC ACID. Distil uric acid concretions in a retort, and silvery white plates sublime, which are the pyrolitheate of ammonia. Dissolve these, and pour the solution into a solution of the sub-acetate of lead, and a pyrolithate of lead falls to the bottom; wash this, and decompose it by sulphuretted hydrogen gas, and the supernatant liquor will be a solution of pyrolithic acid, which yields small acicular crystals by evaporation. Nitric acid dissolves it without changing its properties, which is a distinction between it and lithic acid, which, when so treated, becomes of a purple colour.

PYROMALIC ACID, is obtained from the malic or sorbic acid, by distilling in a retort. An acid sublimated in the form of white needles, appears in the neck of the retort, and an acid liquid distils into the receiver; which liquid, by evaporation, affords crystals, constituting a peculiar acid, called the pyromalic acid. It has the usual acid properties.

PYROMETER. The mercurial thermometer is an excellent instrument for measuring heat within certain limits; but for high temperatures it is utterly useless—the mercury being changed into vapour, and the whole material of which the instrument is made being destroyed. To accomplish the measurement of the great heat of furnaces, Mr. Wedgwood invented his pyrometer, upon the principle that clay regularly and progressively contracted its dimensions as it was exposed to greater degrees of heat. He formed cylindrical pieces of white porcelain clay in a mould, which, when baked in a dull red heat, just fitted the opening of two brass bars, so placed as to form a tapering space between them. This space is graduated, and the farther the clay can enter the greater is the heat indicated. The converging sides are 0·5 of an inch, at the commencement of the scale, and 0·3 at its end.—To establish a connexion between the indications of his thermometer, and those of the mercurial thermometer, he employed a heated rod of silver, of which he measured the expansion. The clay-piece and silver rod were heated in a muffle. When the muffle appeared of a low red heat, such as was judged to come fully within the province of his thermometer, it was drawn forward toward the door of the oven; and its own door being then nimbly opened by an assistant, Mr. Wedgwood pushed the silver piece as far as it would go. But as the division which it went to could not be distinguished in that ignited state, the muffle was lifted out by means of an iron rod passed through two rings made for that purpose, with care to keep it steady, and avoid any shake that might endanger the displacing of the silver piece. When the muffle was grown sufficiently cold to be examined, he noted the degree of expansion which the silver piece stood at, and the degree of heat shown by the thermometer pieces measured in their own gauge; then returned the whole into the oven as before, and

repeated the operation with a stronger heat, to obtain another point of correspondence on the two scales. The first was at 2½° of his thermometer, which coincided with 66° of the intermediate one; and as each of these last had been before found to contain 20° of Fahrenheit's, the 66 will contain 1320; to which add 50, the degree of his scale to which the (0) of the intermediate thermometer was adjusted, and the sum 1370 will be the degree of Fahrenheit's corresponding to his 2½°. The second point of coincidence was at 6½° of his, and 92° of the intermediate; which 92 being, according to the above proportion, equivalent to 1840 of Fahrenheit, add 50 as before to this number, and his 6½° is found to fall upon the 1890th degree of Fahrenheit. It appears hence that an interval of four degrees upon Mr. Wedgwood's thermometer is equivalent to an interval of 520° upon that of Fahrenheit; and, consequently, one of the former to 130° of the latter; and that the (0) of Mr. Wedgwood corresponds to 1077½° of Fahrenheit.—From these data it is easy to reduce either scale to the other through their whole range; and from such reduction it will appear, that an interval of near 480° remains between them, which the intermediate thermometer serves as a measure for; that Mr. Wedgwood's includes an extent of about 32080 of Fahrenheit's degrees, or about 54 times as much as that between the freezing and boiling points of mercury, by which mercurial ones are naturally limited; that if the scale of Mr. Wedgwood's thermometer be produced downward, in the same manner as Fahrenheit's has been supposed to be produced upward, for an ideal standard, the freezing point of water would fall nearly on 8° below (0) of Mr. Wedgwood's, and the freezing point of mercury a little below 8½°; and that, therefore, of the extent of now measurable heat, there are about 5-10ths of a degree of his scale from the freezing of mercury to the freezing of water; 8° from the freezing of water to full ignition; and 160° above this to the highest degree he has hitherto attained. Mr. Wedgwood concludes his account with the following table of the effects of heat on different substances, according to Fahrenheit's thermometer, and his own:—

	Fahr.	Wedg.
Extremity of the scale of his thermometer	32277°	240°
Greatest heat of his small air furnace	21877	160
Cast-iron melts	17977	130
Greatest heat of a common smith's forge	17327	125
Welding heat of iron, greatest	13427	95
Welding heat of iron, least	12777	90
Fine gold melts -	5237	32
Fine silver melts	4717	28
Swedish copper melts	4587	27
Brass melts -	3807	21
Heat by which his enamel colours are burnt on	1857	6
Red heat, fully visible in daylight	1077	0
Red heat, fully visible in the dark	947	— 1
Mercury boils -	600	$3\frac{673}{1000}$
Water boils -	212	$6\frac{658}{1000}$
Vital heat	97	$7\frac{542}{1000}$
Water freezes -	32	$8\frac{42}{1000}$
Proof spirit freezes	0	$8\frac{289}{1000}$
The point at which mercury congeals, consequently the limit of mercurial thermometers, about	40	$8\frac{596}{1000}$

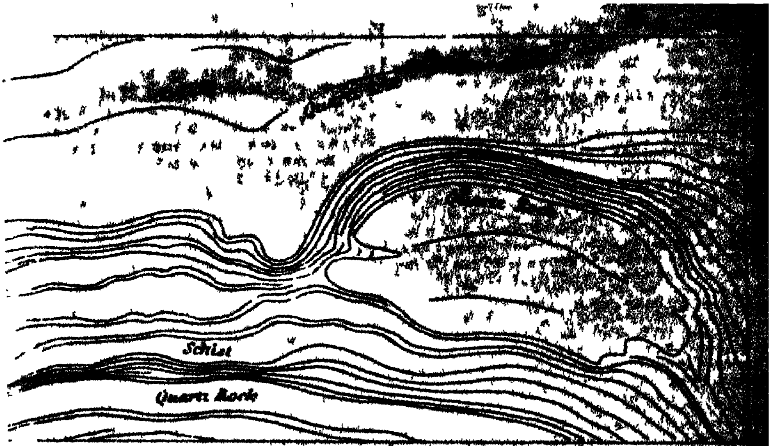
In a scale of HEAT drawn up in this manner, the comparative extents of the different departments of this grand and universal agent are rendered conspicuous at a single glance of the eye. We see at once, for instance, how small a portion of it is concerned in animal and vegetable life, and in the ordinary operations of nature. From freezing to vital heat is barely a five-hundredth part of the scale; a quantity so inconsiderable, relatively to the whole, that in the higher stages of ignition, ten

times as much might be added or taken away, without the least difference being discernible in any of the appearances from which the intensity of fire has hitherto been judged of. Hence, at the same time, we may be convinced of the utility and importance of a physical measure for these higher degrees of heat, and the utter insufficiency of the common means of discriminating and estimating their force. Mr. Wedgwood adds, that he has often found differences, astonishing when considered as a part of this scale, in the heats of his own kilns and ovens, without being perceivable by the workmen at the time, or till the ware was taken out of the kiln.

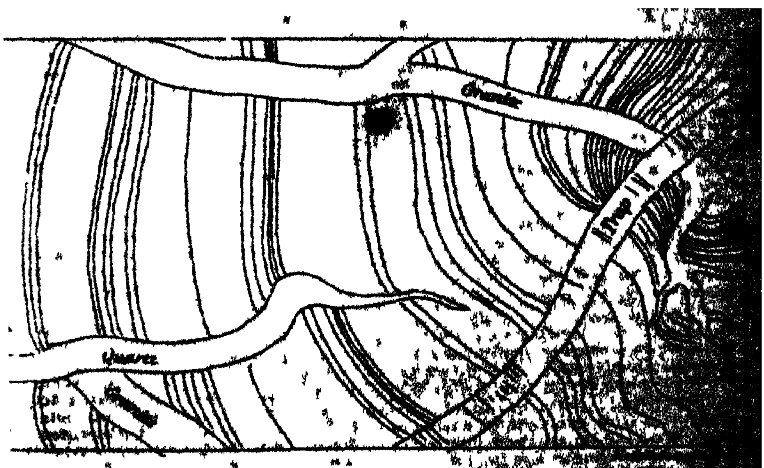
PYROTARTARIC ACID. To obtain this acid introduce tartar, or rather tartaric acid, into a coated glass retort, which is fitted to a tubulated receiver. Let heat be applied, and gradually increased to redness, and pyrotartaric acid of a brown colour, from impurity, will be found in the liquid products. This is to be filtered through paper, to separate the oily part. It is to be evaporated, dissolved, and filtered several times till all the oil be separated; it is then to be treated at a moderate heat with dilute sulphuric acid. At first acetic acid passes into the receiver; but towards the end there is condensed in the retort a white foliated sublimate, which is pure pyrotartaric acid. It has the usual acid properties.

PYROPHORUS. By this name is denoted an artificial product, which takes fire or becomes ignited on exposure to the air. Hence, in the German language, it has obtained the name of luft-zunder, or air tinder. It is prepared from alum by calcination, with the addition of various inflammable substances. Homberg was the first that obtained it, which he did accidentally in the year 1680, from a mixture of human excrement and alum, upon which he was operating by fire. The preparation is managed in the following manner:—three parts of alum are mixed with from two to three parts of honey, flour, or sugar; and this mixture is dried over the fire in a glazed bowl, or an iron pan, diligently stirring it all the while with an iron spatula. At first this mixture melts, but by degrees it becomes thicker, swells up, and at last runs into small dry lumps. These are triturated to powder, and once more roasted over the fire, till there is not the least moisture remaining in them, and the operator is well assured that it can liquefy no more: the mass now looks like a blackish powder of charcoal. For the sake of avoiding the previous above-mentioned operation, from four to five parts of burned alum may be mixed directly with two of charcoal powder. This powder is poured into a phial or matrass, with a neck about six inches long. The phial, which, however, must be filled three-quarters full only, is then put into a crucible, the bottom of which is covered with sand, and so much sand is put round the former that the upper part of its body also is covered with it to the height of an inch; upon this the crucible, with the phial, is put into the furnace, and surrounded with red-hot coals. The fire, being now gradually increased till the phial becomes red-hot, is kept up for the space of about a quarter of an hour, or till a black smoke ceases to issue from the mouth of the phial, and instead of this a sulphureous vapour exhales, which commonly takes fire. The fire is kept up till the blue sulphureous flame is no longer to be seen; upon this the calcination must be put an end to, and the phial closed for a short time with a stopper of clay or loam. But as soon as the vessel is become so cool as to be capable of being held in the hand, the phial is taken out of the sand, and the powder contained in it transferred as fast as possible from the phial, into a dry and stout glass made warm, which must be secured with a glass stopper.—We have made a very good pyrophorus by simply mixing three parts of alum with one of wheat-flour, calcining them in a common phial till the blue flame disappeared: and have kept it in the same phial, well stopped with a good cork when cold.—If this powder be exposed to the atmosphere, the sulphuret attracts moisture from the air, and generates sufficient heat to kindle the carbonaceous matter mingled with it.

PYROPE, a garnet, which crystallizes in the form of a dodecahedron.



Contortion of Schist and Quartz Rock in Scarba.



Gneiss shifted by a Quartz vein in [illegible]

PYROPHYSALITE. See *Physalite*.

PYROSMALITE, a mineral of a liver-brown colour, consisting of peroxide of iron 21·81, protoxide of manganese 21·14, sub-muriate of iron 14·09, silica 35·85, lime 1·21, water and loss 5·9.

PYROXENE augite.

Q.

QUARTATION, is an operation by which the quantity of one thing is made equal to a fourth part of the quantity of another thing. Thus, when gold alloyed with silver is to be parted, we are obliged to facilitate the action of the aquafortis by reducing the quantity of the former of these metals to one-fourth part of the whole mass; which is done by sufficiently increasing the quantity of the silver, if it be necessary. This operation is called quartation, and is preparatory to the parting, and even many authors extend this name to the operation of parting.—See *Assay*.

QUARTZ, occurs in masses, in grains, in rolled pieces or pebbles, and in crystals. It is one of the hardest minerals of which mountain masses are composed; it gives plentiful sparks with steel; it breaks with a smart stroke of the hammer; the surface of the fracture in crystallized quartz is conchoidal in uncrystallized splintery: the lustre is vitreous. Crystals of quartz, or rock crystals, as they are commonly denominated, have different degrees of transparency; the blue varieties are amethysts. The most common forms of the crystals are six-sided prisms terminated by six-sided pyramids, or two six-sided pyramids united, forming a dodecahedron whose faces are isosceles triangles. Uncrystallized quartz is seldom transparent, most frequently translucent, but sometimes opaque. Its colours are various shades of white, grey, brown, yellow, red, and green. It yields a phosphorescent light and peculiar odour when rubbed. Quartz is composed of siliceous earth combined with a very small portion of alumine. It is infusible when unmixed, but with alkalies it melts easily, and forms the well known substance called glass. It is not acted upon by any acid except the fluoric. Quartz exists in veins intersecting mountains, and it sometimes forms large beds, and even entire mountains, which are composed of this mineral in grains united without a cement, called granular quartz. Fragments or crystals of quartz are common in compound rocks. Grains of quartz form a principal constituent part of most sand-stones. The milk-white pebbles in gravel are composed of quartz. Flint, chert, or horn-stone, opal, chalcedony, and agate, are different modifications of siliceous earth, which in their chemical composition differ little from quartz. Combined with a large portion of alumine and iron, quartz loses its translucency and passes into jasper, which forms beds in primitive mountains, and is said to compose the substance of entire ranges of mountains in Asia. Professor Jameson divides quartz into two species, rhomboidal quartz and indivisible quartz, and each of these into numerous sub-divisions.

1. Rhomboidal quartz contains 14 sub-species.

1. Amethyst.	8. Iron flint.
2. Rock crystal.	9. Hornstone.
3. Milk quartz.	10. Flinty slate.
4. Common quartz.	11 Flint.
5. Prase.	12. Calcedony.
6. Cat's eye.	13. Heliotrope.
7. Fibrous quartz.	14. Jasper.

2. Indivisible quartz contains nine sub-species.

1. Float-stone.	6. Obsidian.
2. Quartz-sinter.	7. Pitchstone.
3. Hyalite.	8. Pearlstone.
4. Opal.	9. Pumice-stone.
5. Menilite.	

QUERCITRON, a wood used in dyeing.

QUICKSILVER, a name for mercury.

R.

RADICAL, that which is considered as constituting the distinguishing part of an acid, by its union with the acidifying principle, or oxygen, which is common to all acids. Thus, sulphur is the radical of the sulphuric and sulphurous acids. It is sometimes called the base of the acid, but base is a term of more extensive application.

RADICAL VINEGAR.—See *Acetic Acid*.

RAIN. This phenomenon some philosophers have attributed entirely to the influence of the electric fluid, and this explanation has been rendered the more probable by the circumstance of most abundant showers usually accompanying a thunder storm. It has been considered by meteorologists that the phenomena of a thunder storm were merely a more than usually great exertion of those energies which clouds exert upon each other at all times in a silent tranquil manner, for the beneficial purposes of carrying on the usual operations of nature. It has been observed, that in the formation of the rain-cloud, the superior masses spread in all directions until they become one stratus or uniform sheet. The cumulus also brought under the latter is immediately in rapid motion, and visibly decreases. The cirri also have much the appearance of conductors of electricity. Clouds have been found, by the experiment of elevating a kite, to be charged with different kinds of electricity; and these clouds, when they approach, mutually operate on each other so as to occasion their partial and entire destruction, and precipitate their contents to the earth in the form of rain.—Such is the explanation given, which is evidently better suited to the case of a single shower than of long continued rain, for which it appears very insufficient. Its supporters, however, imagine that the supply of each kind of cloud may be kept up in proportion to the consumption. It is certain, that there is much evaporation going on during the fall of long continued rain, and this may supply the lower clouds with moisture, whilst the upper clouds may also receive supplies by vapour, brought by a superior current from the higher regions of the atmosphere. It is not, however, very easy to conceive how this operation can go regularly on for such a length of time as rains frequently continue; and although it is apparent that electricity is an agent of nature, in the production of this phenomenon, it cannot be considered as the sole agent, or even as having the principal share in the production of rain. It must be considered merely as a secondary agent, modifying two other much more powerful causes—the influx of vapour, and the diminution of temperature.—It is worthy of observation, that much the largest quantity of rain falls in that time of the year when the air appears clearest, and when, from the heat, the appearance of moisture on the ground soon disappears: also, that in warmer countries than ours, and where the air appears much clearer, the quantity of rain which falls greatly exceeds that in this country. The phenomenon of rain has puzzled philosophers very much; and the cause of the difficulty seems to have been, that they have endeavoured to find some *one* cause to which, at all times, to ascribe rain. In this they have failed, and whilst different solutions have been given to the inquiry, which have suited well particular cases, no universal cause has been found out. In fact, it is not reasonable to expect it, and rain at one time may be occasioned by one cause, and at another, under different circumstances, by a different cause. Very frequently rain is produced by the concussion or condensation of two clouds, the one positively, and the other negatively, electrified; and this has been proved by experiments with a kite elevated to a great height in the air. There is no necessity to maintain that rain can never be produced in any other manner. Mr. Dalton, of Manchester, has paid much attention to the subject of meteorology, and the following extracts from a paper read before the Manchester Society, are entitled to every degree of respect.

Mean Monthly and Annual Quantities of Rain at various Places, being the Averages for many Years, by Mr. Dalton.

	Manchester, 33 years.	Liverpool, 18 years.	Chatsworth, 16 years.	Lancaster, 20 years.	Kendal, 25 years.	Dumfries, 16 years.	Glasgow, 17 years.	London, 40 years.	Paris, 15 years.	Viviers, 40 years.	General average.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Fr. In.	Fr. In.	Inch.
January	2·310	2·177	2·196	3·461	5·299	3·095	1·565	1·464	1·228	2·477	2·530
February	2·568	1·847	1·652	2·995	5·126	2·837	1·711	1·250	1·232	1·700	2·295
March	2·098	1·523	1·322	1·753	3·151	2·164	1·184	1·172	1·190	1·927	1·748
April	2·010	2·104	2·078	2·180	2·986	2·017	0·979	1·279	1·185	2·686	1·9[illegible]
May	2·895	2·573	2·118	2·460	3·480	2·568	1·641	1·636	1·767	2·931	2·397
June	2·502	2·816	2·286	2·512	2·722	2·074	1·513	1·738	1·697	2·562	2·315
July	3·697	3·663	3·006	4·140	4·959	3·256	2·306	2·448	1·800	1·882	3·115
August	3·665	3·311	2·435	4·581	5·039	3·199	2·746	1·807	1·900	2·347	3·10[illegible]
September	3·281	3·654	2·289	3·751	4·874	4·350	1·717	1·842	1·550	4·140	3·135
October	3·922	3·721	3·079	4·151	5·439	4·243	2·297	2·092	1·780	4·711	3·537
November	3·360	3·441	2·634	3·775	4·785	3·174	1·904	2·222	1·720	4·187	3·120
December	3·832	3·288	2·569	3·955	6·084	3·142	1·981	1·736	1·600	2·397	3·058
	33·140	34·118	27·664	39·714	53·944	3[illegible]·919	21·331	20·686	18·[illegible]	33·977	

" Every one must have noticed an obvious connexion between heat and the vapour in the atmosphere. Heat promotes evaporation, and contributes to retain the vapour when in the atmosphere, and cold precipitates or condenses the vapour. But these facts do not explain the phenomenon of rain, which is as frequently attended with an increase as with a diminution of the temperature of the atmosphere.

" The late Dr. Hutton, of Edinburgh, was, I conceive, the first person who published a correct notion of the cause of rain.—(See Edin. Trans. vol. i. and ii. and Hutton's Dissertations, &c.) Without deciding whether vapour be simply expanded by heat, and diffused through the atmosphere, or chemically combined with it, he maintained from the phenomena that the quantity of vapour capable of entering into the air increases in a greater ratio than the temperature; and hence he fairly infers, that whenever two volumes of air of different temperatures are mixed together, each being previously saturated with vapour, a precipitation of a portion of vapour must ensue, in consequence of the mean temperature not being able to support the mean quantity of vapour.

"The cause of rain, therefore, is now, I consider, no longer an object of doubt. If two masses of air of unequal temperatures, by the ordinary currents of the winds, are intermixed, when saturated with vapour, a precipitation ensues. If the masses are under saturation, then less precipitation takes place, or none at all, according to the degree. Also the warmer the air, the greater is the quantity of vapour precipitated in like circumstances. Hence the reason why rains are heavier in summer than winter, and in warm countries than in cold.

"We now inquire into the cause why less rain falls in the first six months of the year than in the last six months. The whole quantity of water in the atmosphere in January is usually about three inches, as appears from the dew point, which is then about 32°. Now the force of vapour at that temperature is 0·2 of an inch of mercury, which is equal to 2·8 or three inches of water. The dew point in July is usually about 58° or 59°, corresponding to 0·5 of an inch of mercury, which is equal to seven inches of water; the difference is four inches of water, which the atmosphere then contains more than in the former month. Hence, supposing the usual intermixture of currents of air in both the intervening periods to be the same, the rain ought to be four inches less in the former period of the year than the average, and four inches more in the latter period, making a difference of eight inches between the two periods, which nearly accords with the preceding observations."

In 1794, sir Richard Phillips published a plan for artificially disturbing the electricity of the clouds, and making them fall when rain might be required in a country, or pass over when not wanted. He conceives that nature's conductors are the points of the leaves of all vegetation, particularly of trees, and that more perfect metallic conductors raised to greater heights in the atmosphere, might be so combined as to produce more certain effects. Pursuing this idea, he traces to the cutting down trees in civilized countries their ultimate sterility; and conceives that to this may be ascribed the present sterility of the once most fertile but now desert regions of Syria, Chaldea, and Barbary; and he ascribes the oases of the desert to the circumstance of a few trees being accidentally suffered to grow on them. He imagines, that those countries might now be restored, by erecting on their elevated surfaces a sufficient number of metallic rods to arrest the clouds, and produce sufficient rain to sustain vegetation, and refill the almost exhausted rivers. Such are the errors of ignorance, in depriving a country of its trees, and such the advantages which may result from a due application of the principles of philosophy. The preceding theory may appear fanciful, but it is confirmed by what takes place in nature. Thus, the first lands over which prevailing winds blow from the ocean are always the best watered; and those farther off are less watered in proportion to their distance. The western counties of Ireland, Ireland itself with respect to England, and the western counties of England with reference to the eastern ones, prove the powers of the innumerable spiculæ of vegetation and minerals to disturb the electricity of the clouds, and make them fall in rain. From like causes, according to sir W. Young, the value of estates in several of the West India islands has been greatly diminished by cutting down the trees. The phenomena of Peru and Chili, in the neighbourhood of the elevated natural conductors, the Andes, afford also a lesson to man, whenever the state of society enables him to adopt it. The mean annual quantity of rain is greatest at the equator, and decreases gradually as we approach the poles. Thus, at

Grenada, West Indies, it is				126 inches.
Cape Francois	-	-		120
Calcutta	-	-	-	81
Rome	-	-	-	39
England	-	-	-	35
Petersburgh		-	-	16

The number of rainy days is smallest at the equator, and increases in proportion to the distance from it. The mean number from north latitude 12° to 43°, being 78; from 43° to 46°, being 103; from 46° to 50°, being 134; from 51° to 60°, 161. The number of rainy days is often more in winter than in summer, but the quantity of rain is greater in summer than in winter. At Petersburgh the num-

ber of rainy or snowy days during winter is 81, and the quantity which falls is only about five inches; during summer the number of rainy days is nearly the same, but the quantity which falls is about eleven inches. More rain falls in mountainous countries than in plains. Among the Andes it rains almost continually, while in Egypt it hardly ever rains at all. These well known facts confirm the hypothesis of sir Richard Phillips.

RANCIDITY. The change which oils undergo by exposure to the air. The rancidity of oils is probably an effect analogous to the oxidation of metals. It essentially depends on the combination of oxygen with the extractive principle, which is naturally united with the oily principle. This inference is proved by attending to the processes used to counteract or prevent the rancidity of oils.

REAGENT. In the experiments of chemical analysis, the component parts of bodies may either be ascertained in quantity as well as quality, by the perfect operations of the laboratory, or their quality alone may be detected by the operations of certain bodies called reagents. Thus the infusion of galls is a reagent, which detects iron by a dark purple precipitate; the prussiate of potash exhibits a blue with the same metal, &c.

REALGAR, sulphate of arsenic, a native ore.

RECEIVER. Receivers are chemical vessels, which are adapted to the necks or beaks of retorts, alembics, and other distillatory vessels, to collect, receive, and contain the products of distillations.

RED CHALK, a kind of clay ironstone.

REDDLE, red chalk.

REDUCTION, or REVIVIFICATION. This word, in its most extensive sense, is applicable to all operations, by which any substance is restored to its natural state, or which is considered as such; but custom confines it to operations by which metals are restored to their metallic state, after they have been deprived of this, either by combustion, as the metallic oxides, or by the union of some heterogeneous matters which disguise them, as fulminating gold, luna cornea, cinnabar, and other compounds of the same kind. These reductions are also called revivifications.

REGULUS. The name regulus was given by chemists to metallic matters when separated from other substances by fusion. This name was introduced by alchemists, who, expecting always to find gold in the metal collected at the bottom of their crucibles after fusion, called this metal, thus collected, regulus, as containing gold, the king of metals. It was afterwards applied to the metal extracted from the ores of the semimetals, which formerly bore the name that is now given to the semi-metals themselves. Thus we had regulus of antimony, regulus of arsenic, and regulus of cobalt.

RESIN. The name resin is used to denote solid inflammable substances, of vegetable origin, soluble in alcohol, usually affording much soot by their combustion. They are likewise soluble in oils, but not at all in water, and are more or less acted upon by the alkalis. All the resins appear to be nothing else but volatile oils, rendered concrete by their combination with oxygen. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion. There are some among the known resins which are very pure, and perfectly soluble in alcohol, such as the balsam of Mecca and Capivi, turpentines, tacamahaca, elemi: others are less pure, and contain a small portion of extract, which renders them not totally soluble in alcohol; such are mastic, sandarach, guaiacum, labdanum, and dragon's blood. What is most generally known by the name of resin simply, or sometimes of yellow resin, is the residuum left after distilling the essential oil, from turpentine. If this be urged by a stronger fire, a thick balsam, of a dark reddish colour, called balsam of turpentine, comes over, and the residuum, which is rendered blackish, is called black resin, or colophony. Resin, analyzed by MM. Gay Lussac and Thenard, was found to consist of

Carbon,	75·944	
Hydrogen,	10·719	water 15·156
Oxygen,	13.337	hydrogen in excess 8 9.

The resin of fir is known by the name of rosin. Its properties are well known.

Its specific gravity is 1072. It melts readily, burns with a yellow light, throwing off much smoke. Resin is insoluble in water, either hot or cold, but very soluble in alcohol. When a solution of resin in alcohol is mixed with water, the solution becomes milky; the resin is deposited by the stronger attraction of the water for the alcohol. Resins are obtained from many other species of trees. Mastich from the pistacia lentiscus; elemi from the amyris elemifera; copal from the rhus copallinum; sandarach from the common juniper. Of these resins copal is the most peculiar. It is the most difficultly dissolved in alcohol; and for this purpose must be exposed to that substance in vapour; or the alcohol employed must hold camphor in solution. According to Gay Lussac and Thenard, 100 parts of common resin contain,

Carbon - - - - -	75·944
Oxygen - - - -	13·337
Hydrogen - - - -	10·719

or of

Carbon - - - - -	75·944
Oxygen and hydrogen, in the proportions necessary to form water - - - -	15·156
Hydrogen in excess	8·900

According to the same chemists, 100 parts of copal consist of

Carbon - - - -	76·811
Oxygen - - - -	10·606
Hydrogen - - - -	12·583

or,

Carbon - - -	76·811
Water or its elements	12·052
Hydrogen - - - -	11·137

From these results, if resin be a definite compound, it may be supposed to consist of 8 proportions of carbon, 12 of hydrogen, and 1 of oxygen. Resins are used for a variety of purposes. Tar and pitch principally consist of resin in a partially decomposed state. Tar is made by the slow combustion of the fir, and pitch by the evaporation of the more volatile parts of tar. Resins are employed as varnishes, and for these purposes are dissolved in alcohol or oils. Copal forms one of the finest. It may be made by boiling it in powder with oil of rosemary, and then adding alcohol to the solution.

RESPIRATION, is the act of receiving a portion of air into the lungs, and again emitting it. The blood of the veins is charged with a portion of carbon, which it emits in the lungs, and this carbon uniting with the oxygen received in the lungs, forms carbonic acid gas, and is emitted, as is also the nitrogen or azote. The volume of carbonic acid discharged is exactly equal in bulk to the oxygen which has disappeared; and it is hence supposed that no oxygen is absorbed by the lungs; but other philosophers have been of that opinion, and have supposed that the change of the colour of purple of the venous blood into red, in the arterial blood, which takes place on passing through the lungs, was attributable to the absorption of oxygen; whilst, on the other hand, this has been attributed solely to the discharge of the carbon. An ordinary sized man consumes about 46,000 cubic inches of oxygen per diem, and makes 20 respirations in a minute. The quantity of carbonic acid formed during respiration is diminished after swallowing intoxicating liquors, or under a course of mercury, nitric acid, or vegetable diet.

RETINITE, a mineral, consisting of resin 55, asphaltum 42, earth 3. It is found adhering to coal, at Bovey Tracey in Devonshire.

RETORT. Retorts are vessels employed for many distillations, and most frequently for those which require a degree of heat superior to that of boiling water. This vessel is a kind of bottle with a long neck, so bent, that it makes with the belly of the retort an angle of about sixty degrees. From this form they have probably been named retorts.

REUSSITE a mineral, consisting of six-sided prisms, and of which the constituents are sulphate of soda 66·04, sulphate of magnesia 31·35, muriate of magnesia 3·19, sulphate of lime 0·12.

RHODIUM, a new metal discovered among the grains of crude platina by Dr. Wollaston. The mode of obtaining it in the state of a triple salt combined with muriatic acid and soda, has been given under the article *Palladium*. This may be dissolved in water, and the oxide precipitated from it in a black powder, by zinc. The oxide exposed to heat continues black, but with borax it acquires a white metallic lustre, though it re-

mains infusible. Sulphur or arsenic, however, renders it fusible, and may afterward be expelled by continuing the heat. The button, however, is not malleable. Its specific gravity appears to exceed 11. Rhodium unites easily with every metal that has been tried, except mercury. With gold or silver it forms a very malleable alloy, not oxidated by a high degree of heat, but becoming incrusted with a black oxide when slowly cooled. One-sixth of it does not perceptibly alter the colour of gold, but renders it much less fusible. Neither nitric nor nitro-muriatic acid acts on it in either of these alloys; but if it be fused with three parts of bismuth, lead, or copper, the alloy is entirely soluble in a mixture of nitric acid with two parts of muriatic. The oxide was soluble in every acid Dr. Wollaston tried. The solution in muriatic acid did not crystallize by evaporation. Its residuum formed a rose-coloured solution with alcohol. Muriate of ammonia and of soda, and nitrate of potash, occasioned no precipitate in the muriatic solution, but formed with the oxide triple salts, which were insoluble in alcohol. Its solution in nitric acid likewise did not crystallize, but silver, copper, and other metals precipitated it. The solution of the triple salt with muriate of soda, was not precipitated by muriate, carbonate, or hydrosulphuret of ammonia, by carbonate or ferroprussiate of potash, or by carbonate of soda. The caustic alkalis, however, throw down a yellow oxide, soluble in excess of alkali; and a solution of platina occasions in it a yellow precipitate. The title of this product to be considered as a distinct metal has been questioned; but the experiments of Dr. Wollaston have since been confirmed by Descotils.

RHOMB SPAR, also called bitter spar, and muricalcite, consists of carbonate of lime 56·6, carbonate of magnesia 42, and a minute portion of iron and manganese.

ROCHELLE SALT, tartrate of potass and soda.

ROCKS. There are a variety of terms used in the description of rocks, with which the geologist ought to be familiarly acquainted. A simple rock presents to the sight one unmixed homogeneous substance, whatever be its constituent elementary parts; as limestone, roof-slate, and serpentine. Compound rocks are composed of different mineral substances, either cemented by another mineral substance, as sand-stones and pudding-stones, or aggregated, which implies an intimate union of the parts without a cement, as in granite. The fractured surface of fragments, broken from simple rocks, displays the internal structure of the parts called the stony structure, and is either compact, without any distinguishable parts or divisions, or earthy, comprised of minute parts resembling dried earth,—granular, composed of grains,—fibrous, composed of long and minute fibres,—radiated, when the fibres are broader and flattish, and so large as to be distinctly visible,—lamellar or foliated, composed of thin smooth plates laid over each other,—porous, penetrated by pores,—cellular or vesicular, when the pores have rounded cavities, like bladders, as in some lavas,—slaty, composed of thin leaves, or laminæ. The structure of compound rocks may also be slaty, or granitic, composed of grains or crystals, closely united, without a cement,—porphyritic, consisting of a compact ground, with distinct crystals imbedded, or of a granitic ground, with some crystals much larger than others,—amygdaloidal, composed of a compact ground, with cavities filled with another mineral substance. The external structure of rocks, *en masse*, or considered as mountain masses, is as distinct from the internal as that of a building from that of the bricks or stones. This external structure, as forming mountain masses, may be stratified or stratiform, composed of strata,—tabular, or in large plates,—columnar, or polygonal,—globular, or in spherical masses,—indeterminate, which includes all unstratified rocks without determinate shape. For the Wernerian opinions, which are much followed, respecting the formation of rocks, see *Primary Rocks, Transition Rocks, and Secondary Rocks.*

ROCK-BUTTER, alum mixed with alumine and oxide of iron. It oozes out of rocks containing alum.

ROCK CORK. The same as Asbestos.

ROCK-CRYSTAL. This mineral consists of the purest quartz, being transparent or translucent. It con-

sists of rhomboidal crystals, of which the primitive form has angles of 94° 15 and 85° 45. Specific gravity, 2·6 to 2·8. Its constituents are 99½ silica, and a trace of ferrugineous alumina. The varieties called Venus hairstones by the amateurs, which inclose crystals of Titanium, and Thetis hairstones, which inclose actinolite, sell for a considerable price.

ROCK-SALT. The crystals of rock-salt are of two kinds, foliated and fibrous. The constituents of the Cheshire rock salt are,

Muriate of soda - -	983·25
Sulphate of lime -	6·50
Muriate of magnesia	0·3125
Muriate of lime -	0·0625
Insoluble matter -	9·875
	1000·0000

Rock-salt is considered by the German geologists peculiar to the rock which they call the old red sand-stone. The rock-salt of Cheshire cannot properly be said to lie in or under this rock, but is surrounded by it, and probably rests upon it; but as the lowest bed of salt has not been sunk through, this cannot be yet ascertained. The upper bed of rock-salt in that county is about forty-two yards below the surface; it is twenty-six yards thick, and is separated from the lower bed of salt by a stratum of argillaceous stone ten yards thick. The lower salt has been sunk into forty yards. The upper bed was discovered about 140 years since, in searching for coal. Rock-salt at Northwich extends in a direction from N.E. to S.W. one mile and a half; its further extent in this direction has not been ascertained; its breadth is about 1400 yards. In another part of Cheshire, three beds of rock-salt have been found. The uppermost is four feet, the second twelve feet, and the lower has been sunk into twenty-five yards, but is not cut through. Besides the beds of rock-salt, numerous brine springs, containing more than 25 per cent. of salt, rise in that country. The clear specimens of rock-salt are nearly free from foreign impurities, and contain scarcely any water of crystallization. In sea water a large portion of muriate, and sulphate of magnesia is found, which gives it that bitter nauseous taste distinct from its saltness. This difference in the composition of sea-water and of rock-salt, would seem to indicate that rock-salt was not, as some suppose, produced by the evaporation of sea-water; it is also deserving of notice, that in the strata of rock-salt, at least in Cheshire, few if any remains of marine or other organized bodies are found. In some situations rock-salt forms hills of considerable height, as at Cordova in Spain, where it rises in one solid mass of salt 400 feet above the surface, and three miles in circumference. In the elevated plains of Peru, rock-salt is found 9000 feet above the level of the sea, accompanied with sand-stone and gypsum. Rock-salt and brine springs are met with in various parts of Europe and Asia, in North and South America, in Africa, and also in New South Wales. Salt-springs have been discovered in the coal mines in Northumberland, and in the Ashby-de-la-Zouch coal field, at the depth of 225 yards under the surface. A weaker brine also rises in the upper strata; it springs through fissures in the coal, attended with a hissing noise occasioned by the emission of hydrogen gas. Mr. Bakewell examined these mines belonging to the Earl of Moira, in the summer of 1812; they are situated at Ashby Wolds, in the very centre of England, and what may appear remarkable in this situation, they are worked 140 yards below the level of the sea, which is ascertained from the levels of the canal that passes by the pits. Had this circumstance been known before the attention of geologists was directed to the structure of the earth's surface, it would have been inferred that brine springs so far below the level of the sea had their source from the waters of the ocean penetrating through fissures in the earth. It may be deserving notice, that in the salt mines at Wieleska in Poland, which are the most considerable in the world, the lowest bed, called the szybuker salt, is worked at the depth of 240 yards; but it is not known on what stratum it rests; for the miners, being apprehensive of increasing the quantity of water, have not proceeded to a greater depth. It is stated by the proprietors in Cheshire, that the same fear prevents them from sinking through the lowest bed of salt. Nor

is it known at Cordova in Spain, on what rock the mountain of salt before mentioned rests. According to Brongniart, (Mineralogie) rock-salt and brine springs are generally found at the feet of extensive mountain ranges: he quotes the mines of Transylvania, Upper Hungary, Moldavia, and Poland, as a proof of this assertion. These mines, so important from their number, and the quantity of salt they supply, accompany the Carpathian mountains for more than six hundred miles.

ROCKWOOD. The same as Asbestos.

ROESTONE. A species of limestone, of which Bath stone is an instance.

ROSAIC ACID. The rose-coloured deposit of the urine of persons labouring under fevers.—See *Purpuric Acid*.

RUBY.—See *Sapphire*.

RUST. Red oxide of iron.

RUTILE. An ore of Titanium.

S.

SACLACTATES. Salts formed from the mucic acid and salifiable bases.

SACLACTIC ACID.—See *Mucic Acid*.

SAFETY LAMP. Great care is requisite to keep coal works continually ventilated by perpetual currents of fresh air, to expel the damps and other noxious exhalations. In the deserted works, large quantities of these damps are frequently collected, and often remain for a long time without doing any mischief; but when, by some accident, they are set on fire they produce dreadful and destructive explosions, and burst out from the pits with great impetuosity, like the fiery eruptions from burning mountains. The coal in these mines has several times been set on fire by the fire-damp, and has continued burning many months, until large streams of water were conducted into the mines. Several collieries have been entirely destroyed by such fires, and in some the fire has continued burning for ages. The late Mr. Spedding, having observed that the fulminating damp could only be kindled by flame, and was not liable to be set on fire by red hot iron, nor by the sparks produced by the collision of flint and steel, invented a machine, in which, whilst a steel wheel was turned round with a very rapid motion, flints were applied to it, and by the abundance of fiery sparks emitted, the miners were enabled to carry on their work in places where the flame of a lamp or candle would occasion dreadful explosions. But it was reserved for sir H. Davy to put an entire stop to these destructive ravages of the fire-damp. The carburetted hydrogen gas is that which is so destructive by explosion. By the miners it is called fire-damp, to distingush it from carbonic acid gas, which they call choke-damp. It is disengaged during the working of the coals, from fissures in the strata; and when it has accumulated, so as to form more than one-thirteenth part of the volume of the atmospheric air, it becomes explosive by a lighted candle, or by any kind of flame.

Description of the Safety Lamp. To obviate the destructive effects of this gas, sir Humphrey Davy turned his attention to the construction of a lamp which would prevent explosion; and upon the knowledge of the fact, that flame cannot pass through apertures of small diameter, he constructed what the miners have since, in gratitude, called *the Davy*. The apertures in the gauze should not be more than one-twentieth of an inch square. As the fire-damp cannot be inflamed by ignited wire, the thickness of the wire is not of importance; but wire of one-fortieth to one-sixtieth of an inch in diameter is the most convenient. If the wire of one-fortieth be found to wear out too soon, the thickness may be increased to any extent; but the thicker the wire, the more will the light be intercepted, for the size of the apertures must never be more than one-twentieth of an inch square. In the working model which sir H. Davy sent to the mines, there were 748 apertures in the square inch. When the wire-gauze safe-lamp is lighted and introduced into an atmosphere gradually mixed with fire-damp, the first effect of the fire-damp is to increase the length and size of the flame. When the inflammable gas forms as much as one-twentieth of the volume of air, the cylinder becomes filled with a feeble blue flame; but

the flame of the wick appears burning brightly within the blue flame, and the light of the wick continues, until the fire-damp increases to one-sixth or one-fifth, when it is lost in the flame of the fire-damp, which in this case fills the cylinder with a pretty strong light. As long as any explosive mixture of gas exists in contact with the lamp, so long it will give light, and when it is extinguished, (which happens when the foul air constitutes as much as one-third of the volume of the atmosphere) the air is no longer proper for respiration. In cases in which the fire-damp is mixed only in its smallest explosive proportion with air, the use of the wire-gauze safe-lamp, which rapidly consumes the inflammable gas, will soon reduce the quantity below the explosive point; and it can scarcely ever happen that a lamp will be exposed to an explosive mixture containing the largest proportion of fire-damp; but even in this case, the instrument is absolutely safe; and should the wires become red hot, they have no power of communicating explosion. Should it ever be necessary for the miner to work for a great length of time in an explosive atmosphere by the wire-gauze safe-lamp, it may be proper to cool the lamp occasionally, by throwing water upon the top; or a little cistern for holding water may be attached to the top, the evaporation of which will prevent the heat from becoming excessive. Gas, in a state of flame or combustion, will not pass through brass wire gauze with pores of certain dimensions, although the gas itself, when not in a state of flame, most readily passes. If a piece of wire-gauze be held horizontally over the flame of a common gas-light, the flame of the gas will burn under the wire-gauze, but it will not pass through it in the state of flame. If again, whilst the wire-gauze is held over the flame, a candle be applied to the upper surface of the gauze, the gas passing through it will immediately kindle. The theory is this:—Gas must be heated to a certain degree, either by the immediate contact of flame or some other body, before it will either burn or explode: the gas, in passing through the wire-gauze, loses so much of its heat; or, in other words, the wire-gauze conducts away from it so much of its heat, as to cool it below the degree in which it will burn or explode; hence the important use of the safety lamp, whilst burning in mixtures of atmospheric air and carburetted hydrogen gas. The wire-gauze, with which the lamp is completely surrounded, cools the gas to a degree below the heat necessary for the explosion to take place; and consequently no explosion can happen. In no instance has the safety-lamp been known to fail in preventing explosions in coal mines, whilst the workmen have continued to keep the wire-gauze around it. Respecting several trials which sir H. Davy made with these lamps, he gives the following account, in a letter from Newcastle-upon-Tyne.

"The inspection of a number of wire-gauze safe-lamps, that have been long in common use in the coal-mines, and the examination of the effects of different explosive atmospheres of fire-damp upon them, enable me to offer a few suggestions, which I hope will be of use to the miner.

"The wire-gauze cylinders ought never to be taken out of the screw-piece in which they are fixed; and, in the lamps constructed at Newcastle, which have not the same rim of wire-gauze as those of Newman's construction, the wire-gauze ought to be soldered to the screw-piece, or fixed to it by rivets.

"The wire-gauze is easily cleaned without being detached, by a brush of the same kind as that used for cleaning bottles; and one of these brushes ought to be furnished with every lamp.

"The wire-gauze in several lamps in the collieries, which had been in use six months, and cleaned by careful workmen, without being removed, was as good as new; whereas the gauze in some, that had been used for a much shorter time, and taken out of the lamp and cleaned roughly, was injured at the bottom, and if not actually unsafe, was becoming so.

"In one instance I found a lamp which had been furnished to a workman without a second top. This is a gross and unpardonable instance of carelessness in the maker, who, if any accident had happened, would have been guilty of homicide.

"All the lamps that I have examined have at different times been red

hot; and a workman at the Hepburn colliery shewed me a lamp which, though it had been in use about sixteen hours a-day, for nearly three months, was still in excellent condition; he also said, it had been red hot sometimes for several hours together. Wherever workmen, however, are exposed to such highly explosive mixtures, double gauze-lamps should be used; or a lamp in which the circulation of the air is diminished by a tin-plate reflector placed in the inside, or a cylinder of glass reaching as high as the double wire, with an aperture in the inside; or slips of Muscovy glass may be placed within the lamp, and in this way the quantity of fire-damp consumed, and consequently of heat produced, may be diminished to any extent. Such lamps, likewise, may be more easily cleaned than the simple wire-gauze lamps; for the smoke may be wiped off in an instant from the tin-plate or glass.

"If a blower, or strong current of fire damp is to be approached, double gauze-lamps, or lamps in which the circulation of air is interrupted by slips of metal or glass, should be used, or if the single lamp be employed, it should be put into a common horn or glass lanthorn, the door of which may be removed or open.

"The wire gauze is impermeable to the flame of all currents of fire-damp, as long as it is not heated above redness; but if the iron wire be made to burn, as at a strong welding heat, of course it can be no longer safe; and though such a circumstance can, perhaps, never happen in a colliery, yet it ought to be known and guarded against. And if a workman having a single lamp should accidentally meet a blower acting on a current of fresh air, he ought, on finding his lamp becoming hot, to take it out of the point of mixture, or screen it from the current.

"I have had an excellent opportunity of making experiments on a most violent blower, at a mine belonging to J. G. Lambton, Esq., some of them in the presence of Mr Lambton; in most of them Mr. Buddle assisted. This blower is walled off from the mine, and carried to the surface, where it is discharged with great force. It is made to pass through a leathern pipe, so as to give a stream of which the force was felt at about two feet from the aperture, in a strong current of air. The common single working lamps and double gauze-lamps were brought upon this current, both in the free atmosphere and in a confined air. The gas fired in the lamps in various trials, but did not heat them above dull redness, and when they were brought far into the stream they were finally extinguished.

"A brass pipe was now fixed upon the blower tube, so as to make the whole stream pass through an aperture of less than half an inch in diameter, which of course formed a most powerful blow-pipe, from which the fire-damp, when inflamed, issued with great violence, and a roaring noise, making an intense flame of the length of five feet. The blow-pipe was exposed at right angles to a strong wind, and the double gauze-lamps and single lamps successively placed in it. The double-gauze-lamps soon became red hot at the point of action of the two currents, but the wire did not burn, nor did it communicate explosion. The single gauze-lamp did not communicate explosion as long as it was red hot, and slowly moved through the currents; but when it was fixed at the point of most intense combustion, and reached a welding heat, the iron wire began to burn with sparks, and the explosion then passed.

"In a second and third set of experiments on this violent blow-pipe of fire-damp, single lamps, with slips of tin-plate on the outside, or in the inside, to prevent the free passage of the current, and double lamps, were exposed to all the circumstances of the blast, both in the open air and in an engine-house, where the atmosphere was explosive to a great extent round the pipe, and through which there was a strong current of atmospheric air; but the heat of the wire never approached near the point at which iron wire burns, and the explosion could never be communicated. The flame of the fire-damp flickered and roared in the lamps, but did not escape from its prison.

"There is no reason ever to expect a blow-pipe of this kind in a mine; but if it should occur, the mode of facing it and examining it with most perfect security is shewn; and the

lamp offers a resource which can never exist in a steel mill, the sparks of which would undoubtedly inflame a current of this kind.

"Arguments have been stated as to the weakness of the lamps. In a board or gallery in the Wallsend colliery, Mr. Buddle and myself, with some of the viewers, endeavoured to injure a single gauze-lamp, by throwing large pieces of coal upon it, and striking it with a pick: but we never perforated the gauze; and the lamp, after these severe trials, burnt with perfect security in a small explosive atmosphere made by Mr. Buddle at the bottom of the shaft, for the purpose of trying the lamps.

"I made, with Mr. Buddle and his viewers, some experiments on the comparative light of the lamps, the common miner's candle, and the steel mills, in a gallery in the Wallsend colliery. We judged of the intensity of the light by the square of the distance at which a small object was visible, and made repeated trials on each species of light.

The light of the miner's candle was - - - - - - - - - - -	45·5
That of a lamp furnished with a tin-plate reflector for diminishing the circulation of the air, and facing a blower, was	49·
That of a single common lamp	39·
That of a double copper wire lamp - - - - - - - -	25·
That of the steel mill, very unequal and uncertain, but at its greatest intensity of light	25·

"It may be proper to observe, without reference to the superiority of light, that coals may be worked nearly twice as cheap by the wire-gauze safety-lamp as by the steel mill.

"The pleasure of seeing the wire-gauze safe-lamps in general use amongst the miners, and of adding to the security and happiness of this useful class of men, amply repays me for the labour of twelve months, devoted to their cause, and for the anxiety which I have often experienced during this progress of the investigation.

"*Newcastle, Sep. 9, 1816.*

"H. Davy."

"P. S. I have shewn in the Transactions of the Royal Society, that the power of heated wire gauze to permit the passage of the flame of coal-gas, is directly as the size of the apertures, and to a certain extent, as the velocity of the current; I say, to a certain extent, because, by a current of a certain velocity, flame is extinguished. A very slight motion will pass the flame of coal-gas through wire-gauze, having less than 400 apertures to the square inch, even when it is heated to dull redness; but a very strong current, and an ignition above redness, visible in day-light, is required to pass the same flame through wire-gauze having above 700 apertures to the square inch; and I have never been able to pass the flame of coal-gas, or any carbonaceous flame, through wire-gauze, having more than 1600 apertures to the square inch, by any means.

"The experiments above detailed on the blower, are the first I have made upon currents of fire damp. They prove what I had inferred from its other properties, and they offer simple means of rendering wire-gauze lamps perfectly safe against all circumstances, however extraordinary or unexpected, and of placing their security above the possibility of doubt or cavil."

An improvement of great importance has lately been made to this lamp, by which its utility will be increased. It consists in attaching to the lower part of the wire-gauze a convex lens; the effect of this is, that the miner will have it in his power to direct a strong light upon any particular part where it may be required, while the lens has the further advantage of covering a portion of the gauze, and preserving it from the coal-dust and oil, by which, without considerable care, it is liable to be obstructed.

SAFFLOWER. See *Carthamus.*

SAGENITE, an ore of Titanium.

SAHLITE, a sub-species of augite.

SAL ALEMBROTH.—See *Alembroth.*

SAL AMMONIAC, (NATIVE), a salt found in the vicinity of burning beds of coal, both in England and Scotland, at Solfaterra, Vesuvius, Etna, and other volcanic regions. It consists of muriate of ammonia, with a very minute portion of soda. There is also a native sal-ammoniac formed in beds of clay, along with sulphur, in which there is a minute portion of sulphate

acid. Pure sal-ammoniac consists of muriate of ammonia only.

SAL AMMONIAC, (SECRET).

SULPHATE OF AMMONIA. So called by its discoverer, Glauber.

SAL CATHARTICUS AMARUS. Sulphate of magnesia.

SAL DE DUOBUS. Sulphate of potash.

SAL DIURETICUS. Acetate of potash.

SAL GEM. Native muriate of soda.

SAL GLAUBERI. Sulphate of soda.

SAL MARTIS. Green sulphate of iron.

SAL MIRABILE, or SAL MIRABILE GLAUBERI. Sulphate of soda.

SAL MIRABILE PERLATUM, or SAL PERLATUM. Phosphate of soda.

SAL POLYCHREST GLASERI. Sulphate of potash.

SAL PRUNELLA. Nitrate of potash, cast into flat cakes or round balls, after fusion.

SALIFIABLE BASES, are the alkalis, and those earths and metallic oxides, which have the power of neutralizing acidity, entirely or in part, and producing salts.

SALIVA. The fluid secreted in the mouth, which flows in considerable quantity during a repast, is known by the name of saliva. Saliva, beside water, which constitutes at least four-fifths of its bulk, contains the following ingredients:—

1. Mucilage.
2. Albumen.
3. Muriate of soda.
4. Phosphate of soda.
5. Phosphate of lime.
6. Phosphate of ammonia.

But it cannot be doubted, that, like all the other animal fluids, it is liable to many changes from disease, &c. Brugnatelli found the saliva of a patient labouring under an obstinate venereal disease impregnated with oxalic acid. The concretions which sometimes form in the salivary ducts, &c. and the tartar or bony crusts, which so often attaches itself to the teeth, are composed of phosphate of lime.

SALMIAC. A word sometimes used for sal ammoniac.

SALT. This has been employed as a genuine term to any compound or definite proportions of an acid matter, with an alkali, an earth, or a metallic oxide. When their constituents are so adjusted, that they will not affect the colour of tincture of litmus or red cabbage, it is said to be a neutral salt. If it redden this liquid, there is a predominance of acid, it is said to be acid alone, and it is expressed by the prefix *super* or *bi*. If, however, the acid matter be deficient, there is said to be an excess of base, and this is expressed by the prefix *sub*. This explanation of the constituents of a salt, was rigorously correct, according to the ideas formerly entertained of what were the constituents of an acid; but it is now certain that there are many salts which do not contain either an acid or alkali. Thus muriate of soda, or common salt, is, strictly speaking, a chloride of sodium, and muriate of lime is a chloride of calcium, that is these salts are compounds of chlorine with the metallic bases of sodium and calcium, although they may be formed from the muriatic acid and soda and lime. It is proper to guard the student by these remarks against implicit reception of the explanation given of salts, as being in all cases rigorously correct. It is, however, sufficiently so for ordinary purposes, and where it is not rigorously so, it is so far so as to be closely analogous to the actual fact. Salts are in general soluble in water, but the degree of solubility at different temperatures, and the quantities of water required for the different kinds of salt, are not, as yet, very accurately determined. "In sea salt prepared by rapid evaporation, the insoluble portion is a mixture of carbonate of lime with carbonate of magnesia, and a fine silliceous sand; and in the salt prepared from Cheshire brine, it is almost entirely carbonate of lime. The insoluble part of the less pure pieces of rock salt, is chiefly a marly earth, with some sulphate of lime. The quantity of this impurity is considerably below the average, which in my experiments has varied from 10 to 45 parts in 1000. Some estimates of its general proportion, when ascertained on a larger scale, may be formed from the fact, that Government in levying the duties, allow 65 pounds to the bushel of rock salt, instead of 56 pounds, the usual weight of a bushel

of salt.'—*Henry*, Phil. Trans. for 1810, part 1st. 'The enormous contamination of the Scotch variety with that septic bitter salt, muriate of magnesia, accords perfectly with my own experiments, and is a reproach to the country.

"'That kind of salt then," says this able chemist, "which possesses most eminently the combined properties of hardness, compactness, and perfection of chrystals, will be best adapted to the purpose of packing fish and other provisions, because it will remain permanently between the different layers, or will be very gradually dissolved by the fluids that exude from the provisions; thus furnishing a slow but constant supply of saturated brine. On the other hand, for the purpose of preparing the pickle, or of striking the meat, which is done by immersion in a saturated solution of salt, the smaller grained varieties answer equally well; or, on account of their greater solubility, even better," provided they be equally pure. His experiments shew, that in compactness of texture the large grained British salt is equal to the foreign bay salt. Their antiseptic qualities are also the same.

SALT (AMMONIACAL, FIXED). Muriate of lime.

SALT (AMMONIACAL, SECRET) of Glauber. Sulphate of ammonia.

SALT (ARSENAL, NEUTRAL) OF MACQUER. Superarseniate of potash.

SALT (BITTER, CATHARTIC). Sulphate of magnesia.

SALT (COMMON). Muriate of soda. See *Acid (Muriatic)*; also end of the article *Salt* and *Rock Salt*.

SALT (DIGESTIVE) OF SYLVIUS. Acetate of potash.

'SALT (DIURETIC). Acetate of potash.

SALT (EPSOM). Sulphate of magnesia.

SALT (FEBRIFUGE) OF SYLVIUS. Muriate of potash.

SALT (FUSIBLE). Phosphate of ammonia.

SALT (FUSIBLE) OF URINE. Triple phosphate of soda and ammonia.

SALT (GLAUBER'S). Sulphate of soda.

SALT (GREEN). In the mines of Wieliczka the workmen give this name to the upper stratum of native salt, which is rendered impure by a mixture of clay.

SALT (MARINE). Muriate of soda.

SALT (MARINE, ARGILLACEOUS). Muriate of alumina.

SALT (MICROCOSMIC). Triple phosphate of soda and ammonia.

SALT (NITROUS AMMONIACAL). Nitrate of ammonia.

SALT OF AMBER. Succinic acid.

SALT OF BENZOIN. Benzoic acid.

SALT OF CANAL. Sulphate of magnesia.

SALT OF COLCOTHAR. Sulphate of iron.

SALT OF EGRA. Sulphate of magnesia.

SALT OF LEMONS (ESSENTIAL). Superoxalate of potash.

SALT OF SATURN. Acetate of lead.

SALT OF SEDLITZ. Sulphate of magnesia.

SALT OF SEIGNETTE. Triple tartrate of potash and soda.

SALT OF SODA. Subcarbonate of soda.

SALT OF SORREL. Superoxalate of potash.

SALT OF TARTAR. Subcarbonate of potash.

SALT OF VITRIOL. Purified sulphate of zinc.

SALT OF WISDOM. A compound muriate of mercury and ammonia. See *Alembroth*.

SALT (PERLATE). Phosphate of soda.

SALT (POLYCHREST) OF GLASER. Sulphate of potash.

SALT (SEDATIVE). Boracic acid.

SALT (SPIRIT OF). Muriatic acid was formerly called by this name, which it still retains in commerce.

SALT (SULPHUREOUS) OF STAHL. Sulphate of potash.

SALT (WONDERFUL). Sulphate of soda.

SALT (WONDERFUL PERLATE). Phosphate of soda.

SALTPETRE. Nitrate of potash.

SAND. Sand is an assemblage of small stones.

SAND BATH. See *Bath*.

SANDARIC GUM. A resin in yellowish-white tears, possessing a considerable degree of transparency.

SANDIVER, or GLASS-GALL. This is a saline matter, which rises as a scum in the pots or crucibles in which glass is made.

SAP. The sap of plants, in general, is very compound in its nature; and contains most saccharine, mucilaginous, and albuminous matter in the alburnum; and most tannin and extract in the bark. The cambium, which is the mucilaginous fluid found in trees between the wood and the bark, and which is essential to the formation of new parts, seems to be derived from these two kinds of sap; and probably is a combination of the mucilaginous and albuminous matter of one, with the astringent matter of the other, in a state fitted to become organized by the separation of its watery parts.—The alburnous saps of some trees have been chemically examined by Vauquelin. He found in those of the elm, beech, yoke elm, hornbeam and birch, extractive and mucilaginous matter, acetic acid combined with potass or lime. The solid matter afforded by their evaporation yielded an ammoniacal smell, probably owing to albumen: the sap of the birch afforded saccharine matter.—Deyeux, in the sap of the vine and the yoke elm, has detected a matter analogous to the curd of milk. Sir H. Davy found a substance similar to albumen in the sap of the walnut tree He found the juice, which exudes from the vessels of the marshmallow when cut, to be a solution of mucilage.—The fluids contained in the sap vessels of wheat and barley, afforded, in some experiments which I made on them, mucilage, sugar, and a matter coagulated by heat; which last was most abundant in wheat.

SAPPHIRE. Telesia of Hauy and corundum of Bournon. A valuable mineral of a beautiful blue or red colour, sometimes white, green, and yellow. After the diamond it is the hardest substance in nature. The constituents of the blue sapphire, according to Klaproth, are 98·5, alumina 0·5, lime, and 1 oxide of iron. According to Chenevix, the red sapphire contains alumina 90, lime 7, oxide of iron 1·2, and loss 1·8. It is infusible before the blow-pipe; it becomes electrical when rubbed, and retains its electricity for several hours. Next to the diamond it is the most valuable gem. The white and pale blue varieties, by exposure to heat, become snow-white, and when cut exhibit to a high degree the lustre of the diamond; so that they are often used instead.—The most highly prized varieties are, the crimson and carmine, red sapphire, and the oriental ruby of the jeweller. The next is usually called sapphire. The next the yellow sapphire, or oriental topaz. The asterias, or star-stone, is a beautiful variety. A sapphire of ten carats' weight, *i. e.* forty grains, is said to be worth fifty guineas.

SAPHIRIN. Haüyne.

SARCOLITE, a variety of analcime.

SARDE, or SARDOIN, a variety of carnelian, which displays on its surface an agreeable and rich reddish-brown colour, but appears of a deep blood-red, when held between the eye and the light.

SARDONYX, another variety, composed of layers, of white and red carnelian.

SASSOLINE, native boracic acid. According to Klaproth, it consists of 86 boracic acid, 11 ferruginous sulphate of manganese, and 3 sulphate of lime.

SATIN SPAR, fibrous limestone.

SATURATION. Some substances unite in all proportions. Such, for example, as acids in general, and some other salts with water; and many of the metals with each other. But there are likewise many substances which cannot be dissolved in a fluid, at a settled temperature, in any quantity beyond a certain proportion. Thus water will dissolve only about one-third of its weight of common salt, and, if more be added, it will remain solid. A fluid, which holds in solution as much of any substance as it can dissolve, is said to be saturated with it. But saturation with one substance does not deprive the fluid of its power of acting on and dissolving some other bodies, and in many cases it increases this power. For example, water saturated with salt will dissolve sugar; and water saturated with carbonic acid will dissolve iron, though without this addition its action on this metal is scarcely perceptible. The word saturation is likewise used in another sense by chemists; the union of two

principles produces a body, the properties of which differ from those of its component parts, but resemble those of the predominating principle. When the principles are in such proportion that neither predominates, they are said to be saturated with each other; but if otherwise, the more predominant principle is said to be sub-saturated or under-saturated, and the other super-saturated or over-saturated.

SAUSSURITE, a mineral, found at the foot of Monte Rosa, and so called in honour of Saussure.

SCALES OF FISH, are composed of membrane and phosphate of lime, in alternate layers.

SCALES OF SERPENTS, consist of horny membrane, without the phosphate of lime.

SCAMMONY consists of

	Aleppo.	Smyrna.
Resin	60	29
Gum	3	8
Extractive	2	5
Vegetable debris & earth	35	58
	100	100

Vogel, and Bouillon Lagrange.

SCAPOLITE, is also called Pyramidal Felspar.

SCHILLER SPAR, is of an olive green colour, in granular and distinct concretions. It is found in Unst in Shetland, and Portsoy, in Banffshire.

SCHORL (Common). The black tourmaline of Hauy. Its constituents, according to Klaproth, are, silica 36·75, alumina 34·5, magnesia 0·25, oxide of iron 21, potass 6, and a minute portion of manganese. It is common in granite gneiss, and other primitive rocks: it is sometimes found to form a rock by itself, or mixed with quartz.

SCHORL (Blue), a variety of Haüyne.

SCHORL (Red and Titanic). Rutile.

SCHORLITE, or SCHORLOUS TOPAZ, consists of alumina 51, silica 36·43, fluoric acid 8·84. Berzelius.

SEA SALT, muriate of soda.

SEA WAX, a tallowy-looking substance, found in Lake Baikal.

SEBACIC ACID, an acid supposed to have been found in fat of a strong disgusting odour. M, Thenard states, was merely muriatic or acetic acid, or fat changed some way or other, according to the process employed. This chemist having exposed the error of former chemists, proceeds to give an account of a real sebacic acid, obtained from hogs' lard; but this acid M. Berzelius endeavours to show is merely benzoic acid, contaminated with fat. The eagerness with which chemists hurry from one subject to another, in the hope of being first to make some notable discovery, prevents that rigorous examination of supposed peculiar substances which they meet with, the number of which the progress of science will probably greatly reduce.

SECONDARY ROCKS, are those in which numerous remains of vegetables and animals occur. This division contains sand-stone, coal, stratified lime-stone, chalk, &c. Pebbles and water-worn fragments of rocks belonging to the former divisions are commonly found in many of the secondary rocks: hence it is inferred, that they have been formed at a later period, and hence this class receives its name.

SEDALINE SALT. Boracic acid.

SELDE SEIGNETTE. Tartrate of potash and soda.

SELENITE. Sparry gypsum.

SELENIUM. A new substance discovered by M. Berzelius, which has the properties of a metal combined with those of sulphur, to so great a degree, that it might be supposed to be a new species of sulphur. In its reguline state, it has a brilliant metallic lustre on the external surface, with a tinge of red: the fracture is vitreous like that of sulphur, but with a very brilliant lustre, of a grey colour. At the temperature of boiling water it is softened, and at a higher temperature it melts: it may be distilled at a temperature approaching to that of boiling mercury. Its gas, with which the heated part of the vessel may be filled, is yellow, exactly like that of sulphur. If it be sublimed in a large vessel, it is deposited in the form of flowers, of the colour of cinnabar, which are not, however, in the state of an oxide. During its cooling, it preserves for some time a certain degree of fluidity so that it may be moulded between the fingers, and drawn into threads. The threads, when drawn out to a great de-

gree of fineness, if held between the eye and the light, are transparent, and of a ruby colour; while, by reflected light, they exhibit a brilliant metallic lustre. Its analogy to tellurium has induced him to give it the name of *selenium*. It combines with metals, and generally produces a reddish flame. The alloys have commonly a grey colour, and a metallic lustre. The seleniuret of potassium dissolves in water without evolving any gas, and produces a fluid of a red colour, which has the taste of hydrosulphuret of potass. If diluted muriatic acid be poured upon the seleniuret of potassium, a seleniuretted hydrogen gas is disengaged, which is soluble in water, and precipitates all metallic solutions, even those of zinc and iron. The gas has the odour of sulphuretted hydrogen gas, when it is diluted with air; but, if it be breathed less diluted, it produces a painful sensation in the nose, and a violent inflammation ending in catarrh, which continues for a considerable length of time. Selenium combines with the alkalies, both in the humid way and by fusion: these combinations are red. The seleniurets of barytes and of lime are also red, but they are insoluble. It also dissolves in melted wax, and in the fat oils: the solutions are red, but have no hepatic odour. There exist also hydroseleniurets of the alkalies and of the earths. Selenium may be dissolved in nitric acid by the assistance of heat: the solution, when evaporated and sublimed, yields a mass crystallized in needles, which is a pretty strong acid: it has a pure acid flavour, and forms specific salts with the alkalies, earths, and metallic oxides. The selenic acid is soluble in water and in alcohol: its combinations with potass and ammonia are deliquescent; the latter is decomposed by fire, water is given out, and the selenium is reduced. The selenates of barytes and of lime are soluble in water. The selenic acid, mixed with muriatic acid, is decomposed by zinc, and the selenium is precipitated in the form of a red powder. By sulphuretted hydrogen gas an orange-yellow precipitate is thrown down.

SEMIOPAL. See *Opal*.

SEPTARIA, or LUDI HELMONTII, are concretions of ferruginous marle, from a few inches to a foot in diameter. From this substance Parker's cement for building under water is made.

SEROSITY. See *Blood*.

SERPENTINE. This beautiful stone takes its name from its variegated colours, being supposed to resemble a serpent's skin. It consists of silica 32, magnesia 37·21, alumina 0·5, lime 10·6, iron 0·66, volatile matter and carbonic acid 14·16. The colours are most generally various shades of light and dark green, which are intermixed in spots and clouds: some varieties are red. When fresh broken, it has some degree of lustre, and a slightly unctious feel; when pounded the powder feels soapy. It is harder than lime-stone, but yields to the point of a knife, and will receive a very high polish. When serpentine is found intermixed with patches of crystalline white marble, it constitutes a stone denominated verde-antique, which is highly valued for ornamental sculpture. Some varieties of serpentine are translucent, in others there is an appearance of crystallization, forming a mineral called schiller-spar. The minerals associated with serpentine are generally allied to talc. This rock is found in beds in gneiss and slate rocks, and sometimes covers them; according to Brongniart, there is in the Higher Palatinate, a mountain of magnetic serpentine, in which there is no trace of magnetic iron-stone. Serpentine forms the upper part of Monte Rosa, one of the highest mountains in Switzerland, and is found in many Alpine districts in Europe; but according to Patrin, there is no serpentine in Northern Asia, nor was it observed by Humboldt in the Andes. In Cornwall, this rock occurs with mica-slate lying over the granite, and forms part of the promontory called the Lizard Point. It is not met with in any other part of England; but there are rocks approaching the nature of serpentine in Charnwood forest, and in the county of Radnor in Wales. Beautiful varieties of green serpentine occur in the isle of Anglesea, about six miles from the Paris copper-mine.

SERUM. See *Blood and Milk*.

SHALE. Slate-clay and bituminous slate-clay.

SHELLS. Marine shells may be divided, as Mr. Hatchet observes, into two kinds: those that have a porcel-

anous aspect, with an enamelled surface, and when broken are often in a slight degree of a fibrous texture: and those that have generally, if not always, a strong epidermis, under which is the shell, principally or entirely composed of the substance called nacre, or mother-of-pearl. The porcellanous shells appear to consist of carbonate of lime, cemented by a very small portion of animal gluten. This animal gluten is more abundant in some, however, as in the patellæ. The mother-of-pearl shells are composed of the same substances. They differ, however, in their structure, which is lamellar, the gluten forming their membranes regularly alternating with strata of carbonate of lime. In these two, the gluten is much more abundant. Mr. Hatchet made a few experiments on land shells also, which did not exhibit any differences: but the shells of the crustaceous animals he found to contain more or less phosphate of lime, though not equal in quantity to the carbonate, and hence approaching to the nature of bone. Linnæus therefore, he observes, was right in considering the covering of the echini as crustaceous, for it contains phosphate of lime. In the covering of some of the species of asterias too, a little phosphate of lime occurs; but in that of others there is none.

SHISTUS (ARGILLACEOUS). clay slate.

SIDERITE. Red tourmaline.

SIDERO-CALCITE. Brown spar.

SIDERUM. Phosphuret of iron.

SIENITE. A stone composed of felspar and hornblende, and sometimes quartz and black mica. The transitions by which granite passes into sienite, and the latter into porphyry, trap, and basalt, are gradual, and in some rocks almost imperceptible. These changes are principally effected by an intermixture of the mineral already described under the name of hornblende. This substance forms the connecting link between granitic rocks and those which are of undoubted volcanic origin. It occurs in some granite, and when the quantity increases and supplies the place of quartz, it forms the rock denominated sienite, from Siena in Upper Egypt, where it abounds, and was employed for purposes of architecture and sculpture by the Egyptians and Romans. In sienite the felspar is generally red, and the hornblende black or dark green. When hornblende predominates and the crystals are small, it is called green-stone.

SILICA, SILEX, SILICIUM, or SILICIOUS earth, is one of the most abundant substances in nature, and is the chief component part of sand, sandstone, flints, granite, quartz, porphyry, rock crystal, agates, and many precious stones. It is the substance of which the solid frame of many mountains is composed, and it probably is so of a great part of the globe itself. Its specific gravity is about 2·66. Silex when perfectly pure is a fine powder, hard, insipid, and without smell; rough to the touch, and scratches and wears away glass. When mixed with water it does not form an adhesive soft mass, and soon falls to the bottom, leaving the water clear. If silex be very minutely divided, it may be dissolved in water to a very small degree. To obtain silica perfectly pure for experiments, ignite powdered quartz with three parts of pure potass in a silver crucible, add to the solution enough of acid to saturate the alkali, and evaporate to dryness, and we then have a gritty powder, which when washed with water will be pure silica. Although we cannot dissolve silica artificially, we find it done by nature. The Bath waters and other mineral springs, contain silex in solution in a very small portion. The great springs and water spouts of Geyser in the island of Iceland, which project the water 90 feet high, contain silex dissolved by some process of nature, for the water falling down deposits such a quantity of silicious earth as to form a sort of cup around the spring. In this process the pressure and heat of the water may, perhaps, greatly contribute to the effect. Silica is a very necessary component part in good mortar. When reduced to minute parts, either by nature or art, it is employed in making stone-ware. It is the chief substance of which glass is made, for which purposes it is smelted with the alkaline salts in a great heat. A variety of these salts are used for the purpose, and metals are also frequently employed. Silica, it is probable, is composed of oxygen and a metallic basis, which may be

called silicum. By passing the vapour of potassium over silica in an ignited tube, sir H. Davy obtained a dark coloured powder, which he supposed to be the basis of this earth: but as this substance was decomposed by water, it was impossible to wash away the potass.

SILVAN. Tellurium, according to Werner.

SILVER, is the whitest of all metals, considerably harder than gold, very ductile and malleable, but less malleable than gold; for the continuity of its parts begins to break when it is hammered out into leaves of about the hundred and sixty thousandth part of an inch thick, which is more than one third thicker than gold leaf; in this state it does not transmit the light. Its specific gravity is from 10·4 to 10·5. It ignites before melting, and requires a strong heat to fuse it. The heat of common furnaces is insufficient to oxidize it; but the heat of the most powerful burning lenses vitrifies a portion of it, and causes it to emit fumes; which, when received on a plate of gold, are found to be silver in the metallic state. It has likewise been partly oxidized by twenty successive exposures to the heat of the porcelain furnace at Sevres. By passing a strong electric shock through a silver wire, it may be converted into a black oxide; and by a powerful galvanic battery, silver leaf may be made to burn with a beautiful green light. Lavoisier oxidized it by the blow-pipe and oxygen gas: and a fine silver wire burns in the kindled united stream of oxygen and hydrogen gases. The air alters it very little, though it is disposed to obtain a thin purple or black coating from the sulphureous vapours, which are emitted from animal substances, drains, or putrefying matters. This coating, after a long series of years, has been observed to scale off from images of silver exposed in churches; and was found, on examination, to consist of silver united with sulphur. Silver is soluble in the sulphuric acid when concentrated and boiling, and the metal in a state of division. The muriatic acid does not act upon it, but the nitric acid, if somewhat diluted, dissolves it with great rapidity, and with a plentiful disengagement of nitrous gas; which, during its extrication, gives a blue or green colour to the acid, that entirely disappears if the silver made use of be pure; if it contain copper, the solution remains greenish; and if the acid contain either sulphuric or muriatic acid, these combine with a portion of the silver, and form scarcely soluble compounds, which fall to the bottom. If the silver contain gold, this metal separates in blackish-coloured flocks. The nitric acid dissolves more than half its weight of silver; and the solution is very caustic, that is to say, it destroys and corrodes animal substances very powerfully. The solution of silver, when fully saturated, deposits thin crystals as it cools, and also by evaporation. These are called lunar nitre, or nitrate of silver. A gentle heat is sufficient to fuse them, and drive off their water of crystallization. In this situation the nitrate, or rather subnitrate, for the heat drives off part of the acid, is of a black colour, may be cast into small sticks in a mould, and then forms the lapis infernalis, or lunar caustic used in surgery. A stronger heat decomposes nitrate of silver, the acid flying off, and the silver remaining pure. It is obvious that, for the purpose of forming the lunar caustic, it is not necessary to suffer the salt to crystallize, but that it may be made by evaporating the solution of silver at once to dryness; and as soon as the salt is fused, and ceases to boil, it may be poured out. The nitric acid driven off from nitrate of silver is decomposed, the products being oxygen and nitrogen. The sulphate of silver, which is formed by pouring sulphuric acid into the nitric solution of silver, is sparingly soluble in water; and on this account forms crystals, which are so small, that they compose a white powder. The muriatic acid precipitates from nitric acid the saline compound called luna-cornea, or horn silver; which has been so distinguished, because, when melted and cooled, it forms a semi-transparent and partly flexible mass, resembling horn. It is supposed that a preparation of this kind has given rise to the accounts of malleable glass. This effect takes place with aqua regia, which acts strongly on silver, but precipitates it in the form of muriate, as fast as it is dissolved. If any salt with base of alkali, containing the muriatic acid, be

added to the nitric solution of silver, the same effect takes place by double affinity; the alkaline base uniting with the nitric acid, and the silver falling down in combination with the muriatic acid. Since the muriatic acid throws down only silver, lead, and mercury, and the latter of these two is not present in silver that has passed cupellation, though a small quantity of copper may elude the scorification in that process, the silver which may be revived from its muriate is purer than can readily be obtained by any other means. When this salt is exposed to a low red-heat, its acid is not expelled; and a greater heat causes the whole concrete either to rise in fumes, or to pass through the pores of the vessel. To reduce it, therefore, it is necessary that it should be triturated with its own weight of fixed alkali, and a little water, and the whole afterwards exposed to heat in a crucible, the bottom of which is covered with soda; the mass of muriate of silver being likewise covered with the same substance. In this way the acid will be separated from the silver, which is reduced to its metallic state. As the precipitate of muriate of silver is very perceptible, the nitric solution of silver is used as a test of the presence of muriatic acid in waters: for a drop of this solution poured into such waters will cause a very evident cloudiness. The solution of silver is also used by assayers to purify the nitric acid from any admixture of muriatic acid. In this state they call it precipitated aquafortis. M. Chenevix found, that a chlorate of silver may be formed, by passing a current of chlorine through water in which oxide of silver is suspended; or by digesting phosphate of silver with hyperoxymuriate of alumina. It requires only two parts of hot water for its solution, and this affords on cooling, small white, opaque, rhomboidal crystals. It is likewise somewhat soluble in alcohol. Half a grain, mixed with half as much sulphur, and struck or rubbed, detonates with a loud report and a vivid flash. Compounds of silver with other acids are best formed by precipitation from its solution in nitric acid; either by the acid itself, or by its alkaline salts. Phosphate of silver is a dense white precipitate, insoluble in water, but soluble in an excess of its acid. By heat it fuses into a greenish opaque glass. Carbonate of silver is a white insoluble powder, which is blackened by light. The fluate and borate are equally soluble. Distilled vinegar readily dissolves the oxide of silver, and the solution affords long white needles, easily crystallized. The precipitates of silver, which are formed by the addition of alkalis or earths, are all reducible by mere heat, without the addition of any combustible substance. A detonating powder has been sold lately in London as an object of amusement. It is enclosed between the folds of a card, cut in two lengthways; the powder being placed at one end, and the other being notched, that it may be distinguished. If it be taken by the notched end, and the other be held over the flame of a candle, it soon detonates, with a sharp sound, and violent flame. The card is torn, and changed brown; and the part in contact with the composition is covered with a slight metallic coating, of a greyish-white colour. This compound, which M. Descotils calls detonating silver, to distinguish it from the fulminating silver of M. Berthollet, may be made by dissolving silver in pure nitric acid, and pouring into the solution, while it is going on, a sufficient quantity of rectified alcohol: or by adding alcohol to a nitric solution of silver with considerable excess of acid. In the first case, the nitric acid, into which the silver is put, must be heated gently, till the solution commences, that is, till the first bubbles begin to appear. It is then to be removed from the fire, and a sufficient quantity of alcohol to be added immediately, to prevent the evolution of any nitrous vapours. The mixture of the two liquors occasions an extrication of heat; the effervescence quickly recommences, without any nitrous gas being disengaged; and it gradually increases, emitting at the same time a strong smell of nitric ether. In a short time the liquor becomes turbid, and a very heavy, white, crystalline powder falls down, which must be separated, when it ceases to increase, and washed several times with small quantities of water. If a very acid solution of silver previously made be employed, it must be heated gently, and the alcohol then added. The heat excited by the mixture, which is to be

made gradually, soon occasions a considerable ebullition, and the powder immediately precipitates. It would be superfluous to remind the chemist, that the mixture of alcohol with hot nitric acid is liable to occasion accidents, and that it is consequently prudent to operate on small quantities. This powder has the following properties: It is white and crystalline; but the size and lustre of the crystals are variable. Light alters it a little. Heat, a blow, or long continued friction, causes it to inflame with a brisk detonation. Pressure alone, if it be not very powerful, has no effect on it. It likewise detonates by the electric spark. It is slightly soluble in water. It has a very strong metallic taste. Concentrated sulphuric acid occasions it to take fire, and is thrown by it to a considerable distance. Dilute sulphuric acid appears to decompose it slowly.

Process for separating silver from copper, by Mr. Keir.

Put the pieces of plated metal into an earthen glazed pan; pour upon them some acid liquor, which may be in the proportion of eight or ten pounds of sulphuric acid to one pound of nitre; stir them about, that the surfaces may be frequently exposed to fresh liquor, and assist the action by a gentle heat from 100 to 200 deg. of Fahrenheit's scale. When the liquor is nearly saturated, the silver is to be precipitated from it by common salt, which forms a muriate of silver, easily reducible by melting it in a crucible with a sufficient quantity of potash; and lastly, by refining the melted silver if necessary, with a little nitre thrown upon it. In this manner the silver will be obtained sufficiently pure, and the copper will remain unchanged. Otherwise the silver may be precipitated in its metallic state, by adding to the solution of silver a few of the pieces of copper, and a sufficient quantity of water to enable the liquor to act upon the copper. Mr. Andrew Thomson, of Banchory, has recommended the following method of purifying silver, which he observes is equally applicable to gold. The impure silver is to be flatted out to the thinness of a shilling, coiled up spirally, and put into a crucible, the bottom of which is covered with black oxide of manganese. More of this oxide is then to be added, till the silver is completely covered, and all the spaces between the coils filled. A cover is then to be luted on, with a small hole for the escape of the gas; and after it has been exposed to a heat sufficient to melt silver for about a quarter of an hour, the whole of the alloy will be oxidized. The contents of this crucible are then to be poured into a larger, into which about three times as much powdered green glass has been previously put; a cover luted on as before, to prevent the access of any inflammable matter; and the crucible exposed to a heat sufficiently strong to melt the glass very fluid. On cooling and breaking the crucible, the silver will be found reduced at the bottom, and perfectly pure. Sulphur combines very easily with silver if thin plates, imbedded in it, be exposed to a heat sufficient to melt the sulphur. The sulphuret is of a deep violet colour, approaching to black, with a degree of metallic lustre, opaque, brittle and soft. It is more fusible than silver, and this in proportion to the quantity of sulphur combined with it. A strong heat expels part of the sulphur. Sulphuretted hydrogen soon tarnishes the surface of polished silver, and forms on it a thin layer of sulphuret. The alkaline sulphurets combine with it by heat, and form a compound soluble in water. Acids precipitate sulphuret of silver from this solution. Phosphorus, left in a nitric solution of silver, becomes covered with the metal in a dendritic form. By boiling, this becomes first white, then a light black mass, and is ultimately converted into a light brown phosphuret. The best method of forming a phosphuret of silver is Pelletier's, which consists in mixing phosphoric acid and charcoal with the metal, and exposing the mixture to heat. Most metallic substances precipitate silver in the metallic state from its solution. The assayers make use of copper to separate the silver from the nitric acid used in the process of parting. The precipitation of silver by mercury is very slow, and produces a peculiar symmetrical arrangement, called the tree of Diana. In this, as in all precipitations, the peculiar form may be affected by a variety of concomitant circumstances; for which reason one process usually

succeeds better than another. Make an amalgam, without heat, of four drachms of leaf silver with two drachms of mercury. Dissolve the amalgam in four ounces, or a sufficient quantity of pure nitric acid of a moderate strength; dilute this solution in about a pound and a half of distilled water; agitate the mixture, and preserve it for use in a glass bottle with a ground stopper. When this preparation is to be used, the quantity of one ounce is put into a phial, and the size of a pea of amalgam of gold, or silver, as soft as butter, is to be added; after which the vessel must be left at rest. Soon afterwards small filaments appear to issue out of the ball of amalgam, which quickly increase, and shoot out branches in the form of shrubs. Silver unites with gold by fusion, and forms a pale alloy, as has been already mentioned in treating of that metal. With platina it forms a hard mixture, rather yellower than silver itself, and of difficult fusion. The two metals do not unite well. Silver melted with one-tenth part of crude platina, from which the ferruginous particles had been separated by a strong magnet, could not be rendered clear of scabrous parts, though it was repeatedly fused, poured out, and laminated between rollers. It was then fused and suffered to cool in the crucible, but with no better success. After it had been formed, by rolling and hammering, into a spoon for blow-pipe experiments, it was exposed to a low red-heat, and became rough, and blistered over its whole surface. The quantities were one hundred grains of silver, and ten grains of platina. Nitre was added during the fusions. Silver very readily combines with mercury. A very sensible degree of heat is produced, when silver leaf and mercury are kneaded together in the palm of the hand. With lead it forms a soft mass less sonorous than pure silver. With copper it becomes harder and more sonorous, at the same time that it remains sufficiently ductile: this mixture is used in the British coinage. 12½ parts of silver, alloyed with one of copper, form the compound called standard silver. The mixture of silver and iron has been little examined. With tin it forms a compound, which, like that of gold with the same metal, has been said to be brittle, however small the proportion; though there is probably as little foundation for the assertion in the one case as in the other. With bismuth, arsenic, zinc, and antimony, it forms brittle compounds. It does not unite with nickel. The compound of silver and tungsten, in the proportion of two of the former to one of the latter, was extended under the hammer during a few strokes; but afterwards split in pieces. See *Iron*.

The uses of silver are well known: it is chiefly applied to the forming of various utensils for domestic use, and as the medium of exchange in money. Its disposition to assume a black colour by tarnishing, and its softness, appear to be the chief objection to its use in the construction of graduated instruments for astronomical and other purposes, in which a good white metal would be a desirable acquisition. The nitrate of silver, beside its great use as a caustic, has been employed as a medicine, it is said with good success, in epileptic cases, in the dose of 1-20th of a grain, gradually increased to 1-8th, three times a-day. Dr. Cappe gave it in a dose of 1-4th of a grain three times a-day, and afterward four times, in what he supposed to be a case of angina pectoris, in a stout man of sixty, whom he cured. He took it for two or three months. Dr. Cappe imagines, that it has the effect of increasing the nervous power, by which muscular action is excited.

SILVERING. There are various methods of giving a covering of silver or silvery aspect to the surfaces of bodies. The application of silver leaf is made in the same way as that of gold, for which see *gilding*. Copper may be silvered over by rubbing it with the following powder:—Two drachms of tartar, the same quantity of common salt, and half a drachm of alum, are mixed with fifteen or twenty grains of silver precipitated from nitric acid by copper. The surface of the copper becomes white when rubbed with this powder, which may afterwards be brushed off and polished with leather. The saddlers and harness makers cover their wares with tin for ordinary uses, but a cheap silvering is used for this purpose, as follows;—Half an ounce of silver that has been precipitated from aquafortis by

the addition of copper, common salt, and muriate of ammonia, of each two ounces, and one drachm of corrosive muriate of mercury, are triturated together, and made into a paste with water; with this, copper utensils of every kind, that have been previously boiled with tartar and alum, are rubbed, after which they are made red-hot, and then polished. The intention of this process appears to be little more than to apply the silver in a state of minute division to the clean surface of the copper, and afterwards to fix it there by fusion; and accordingly this silvering may be effected by using the argentine precipitate here mentioned, with borax or mercury, and causing it to adhere by fusion. The dial-plates of clocks, the scales of barometers, and other similar articles, are silvered by rubbing upon them a mixture of muriate of silver, sea salt, and tartar, and afterwards carefully washing off the saline matter with water. In this operation, the silver is precipitated from the muriatic acid, which unites with part of the coppery surface. It is not durable, but may be improved by heating the article, and repeating the operation till the covering seems sufficiently thick. The silvering of pins is effected by boiling them with tin filings and tartar. Hollow mirrors or globes are silvered by an amalgam consisting of one part by weight of bismuth, half a part of lead, the same quantity of pure tin, and two parts mercury. The solid metals are to be first fused together and the mercury added when the mixture is almost cold. A very gentle heat is sufficient to fuse this amalgam. In this state it is poured into a clean glass globe intended to be silvered, by means of a paper funnel which reaches to the bottom. At a certain temperature it will stick to the glass, which by a proper motion may thus be silvered completely, and the superfluous amalgam poured out. The appearance of these toys is varied by using glass of different colours, such as yellow, blue, or green.

SINTER, is a deposition of earth previously dissolved in water. Calc sinter, or calcareous sinter, is a deposition of calcareous earth. We have already noticed it under its proper head. Siliceous sinter is less frequent, but is found around the hot springs of Geyser, in the island of Iceland, and also near other hot springs formed by volcanoes. Great abundance is found in the island of St. Michael, one of the Azores, particularly in the valley of Furnas. Wherever the water has flowed, depositions of siliceous sinter have accumulated, and circular basins, composed entirely of this substance, have here and there formed around a spring. The siliceous matter rises in many places eight or ten inches above the level of the water, and is often exceedingly beautiful. Grass, leaves, and other substances, are often encrusted with it. Where the water has dashed irregularly over the basins, the depositions are rough, and often present an appearance similar to those of Iceland, which have been so well compared by sir George Mackenzie to the heads of cauliflowers. The specific gravity varies from 1·88 to 2·11. By analysis it is found to consist of 53·65 silex, and 16·35 water. There is a kind of sinter composed chiefly of aluminous earth.

SLATE, (Adhesive).—See *Clay*.

SLATE-COAL.—See *Coal*.

SLATE-SPAR, or SCHIFFER-SPAR, a species of limestone.

SLICKENSIDES, a mineral found in Derbyshire, which has this remarkable property, that when the rock in which it is contained is struck with a hammer, a crackling noise is heard, which is generally followed by an explosion of the rock in the direction and neighbourhood of the vein.

SMALT.—See *Zaffre*.

SMARAGDITE.—See *Diallage*.

SMARAGDUS.—See *Emerald*.

SOAP. Macquer gives us the following process for oil soap:—One part of quicklime and two parts of good Spanish soda, are boiled together during a short time, with twelve times as much water, in an iron caldron. This lixivium is to be filtered, and evaporated by heat, till a phial, which is capable of containing an ounce of water, shall contain an ounce and three-eighths of this concentrated lixivium. One part of this lixivium is to be mixed with two parts of oil of olives, or of sweet almonds, in a glass or stoneware vessel. The mixture is to be stirred from time to time with an iron spatula, or with a pestle, and

it soon becomes thick and white. The combination is gradually completed, and in seven or eight days a very white and firm soap is obtained. For the coarser sorts of soap, cheaper oils are employed, such as oil of nuts, linseed, hempseed, fish, &c. Either of these kinds of soap, to be good, must neither feel greasy or unctious in water, nor exhibit any vestige of fat upon the water. It ought further to dissolve easily in water, and lather well, as likewise be easily soluble in alcohol. It must not become moist in the air, or throw out a saline efflorescence on its external surface.

For making Brown or Yellow Soap.

Let there be weighed 10 cwt. of tallow, and about 3 cwt. of resin, the resin to be broken into small lumps. In the first place, put into the boiler about 150 or 200 gallons of ley, and set the fire; then add the tallow and resin. This done, the pan is said to be charged. A good fire may be kept up until all is thoroughly melted, and the pan brought to boil; during which time, there ought to be constant stirring with the paddle, to prevent the resin from settling to the bottom. If the goods or materials in the pan appear to swell up, damp the fire, which is done by opening the furnace door, and throwing ashes thereon, (some have proper dampers), when the whole will boil at leisure. As the caustic alkali immediately unites to the tallow, there is no occasion for long boiling; about two or three hours will be long enough. The fire may then be drawn, and the pan allowed to stand for four or six hours, when the weak ley may be pumped off, and fresh added for a second boil. It may be necessary to mention, that when the pan is wished to be cranned or pumped off sooner, a few pails of cold ley must be thrown in, a little after the fire is drawn. Set the fire again for the second boil, and when properly a-boil, two or three hours may be sufficient at any one time to continue the boil. The strength of the ley is often gone before this period arrives. A short experience, however, with attention, will perfectly inform any sagacious person with regard to this particular. The boilings to be thus continued day after day, until the soap becomes thick, and of a strong consistence. Take then a little upon the fore finger, and after letting it cool a few seconds, press it with the thumb. If it squeese into a thin, hard scale, the soap is fit or ready for finishing: if, on the contrary, it appear greasy, and stick to the fingers, and of a soft consistence, more ley must be added; and if this does not harden it, another boil must be given. But, in consequence of the former scaly appearance, give the pan a good hearty boil, and draw the fire. Cool down with two or three pails of ley, and in about two hours thereafter pump off the ley; which should be done at all times as clean as possible. This done, put in six or eight pails of water to the boiler, (no ley at finishing being used), set a brisk fire, and keep constantly stirring with hand-stirrer and paddle, alternately, until all is melted, and begins to show an appearance something like thin honey. Take now a little from a boiling part upon the hand-board, and observe, when held up, if any ley runs clearly from it. If it do, more water must be put in, and the boil continued. When, upon the other hand, no ley runs from the soap when held up slanting-ways upon the board, in this case, too much water has already been given. A little strong solution of salt must now be added to open it, technically termed cutting up; or instead of salt brine, a little strong common salt and water; about half a pailful may do. We come now to the most critical part of boiling, that is, the finishing of the soap: and it ought to be particularly attended to, that the soap be brought to such a state, as when held up upon the hand-board, the ley does not run down from the soap, but is seen, as it were, just starting from it. The fire may then be drawn away, and the soap declared finished: or if palm-oil be wished for making it of a beautiful colour, about 20lbs. may be put into the boiler, after you discover, as above, the soap to be finished: and in about half an hour after the oil is put in, the fire may be drawn, and the whole allowed to stand for forty-eight hours, when it may be cast into the frames. In about three days, (supposing the frames 30 inches deep), the whole will cut up into bars.

A Charge for Pure White Soap.

The boiler being made perfectly

clean, put in 10 cwt. of best home-melted tallow, (no resin is used in white soap), with 200 gallons of ley; melt down with a moderate fire, as the goods now in hand are something similar to milk, exceeding apt to boil over. Close attention, therefore, is absolutely needful upon this first boil, which may be continued about two hours, with a moderate fire, when it may be drawn away, and the pan allowed to settle about two hours, when the ley may be drawn off. The process to be observed in this soap is exactly similar to the last operation. Two or three boils a-day to white soap may be given with great ease; the ley sooner subsiding in the boiler than with yellow soap, and can be cleaner pumped off. When sufficient boils have been given, and the soap is arrived at perfection, it will assume an appearance something like a curdy mass. Take then a little upon your fore-finger, (as before directed), and if the same effect seem to attend it, that is, when pressed with the thumb it squeezes into a thin, hard, clear scale, and parts freely from the finger, the soap is ready for finishing. Draw the fire cool down with a few pails of ley, and in a short time thereafter pump clean off. Set the fire, and add to the soap eight or ten pails of water, (the pail I suppose to contain about nine or ten English gallons). When this is melted, and properly incorporated with the soap, try, as formerly directed, if the ley run from it when held up upon the hand-board. If it do, more water must be put in. If it do not run, or there be no appearance of it, continue boiling for a short while longer, and then add a pail of salt and water pretty strong, mixed together; about one-third salt, and two-thirds water. This will have the effect of cutting up the pan, or separating the soap and water completely from one another. When this is apparent, draw the fire; let it stand for half an hour, when the water will pump off, bringing therewith most of the remaining alkaline ley of the former boil. This I call the first washing, and if kelp ley has been used in the operation, the propriety of this must be conspicuous, for the water pumped off will be of an exceeding dark bottle-green colour. The finishing of white soap without this precaution, is the sole cause of the blueness, so frequently observed in this article when made and brought to market. The blue ley being pumped clean off, set again the fire, and put into the boiler six or eight pails of water; and when thoroughly incorporated and boiled some time, try if the water run from the soap. If it do, add water in small quantities at a time, until it is observed not to run, but as formerly mentioned for yellow soap, to appear as just starting from the soap. In this case, after giving a good boil, and swelling the soap up in the pan to near the brim, draw away all the fire, and spread it about to die away. The pan is now finished, and may stand about twelve or fourteen hours; and if the quantity be large, that is, two, three, or four ton, double this time to stand will be much in favour of the soap, providing always that it can be kept very close and warm in the boiler. If any blueness still appear, repeat the washing. Before casting, I would recommend the frames to have a bottom and lining of coarse cloth, for white soap only. After all is cast into the frames, let it be well stirred, or crutched; and it is very proper that it also be covered close up with old sheets, bass matts, &c. upon the top of the frame and soap, and allowed to cool gradually, and all together. In about three or four days (supposing, as formerly, the dip 30 inches), the coverings and frames may be taken off, and the whole cut up into such size of bars as may best suit the customers. To give this white soap the perfume of what is commonly called Windsor soap, a little of the essential oil of caraway-seeds, mixed with a small portion of alcohol, may be incorporated with the soap when putting into the frame, stirring it in by little at a time, so as to diffuse it throughout the whole mass.

For making Black or Green Soft Soap.

The peculiar method pursued in making this soap, differs considerably from that of making hard soap. The hard has the whole of the ley totally extracted before finishing: soft soap, on the contrary, retains the whole of the ley used in the making; becoming, with the other materials employed, one

compound body, called soft soap. A few examples will clearly explain the nature and practical means made use of in producing this very useful soap. We shall now commence an operation with a charge for what is called *First Crown Soft Soap, 18 barrels.*

The quantity of ley requisite for completion of this charge will be about 400 gallons; about one-third of which must be put into the boiler previous to any of the other materials: afterwards add, 2 cwt. 2 qrs. of tallow, 2 cwt. 2 qrs. of hogs' lard, and 70 gallons of olive oil. The ley herein to be used is supposed to be from Hungarian and English (Essex) ashes. The proportion is one of the English to eight of the Hungarian. The particular mode of proceeding is this: after the ley is put in, add the tallow, and light the fire. When all the tallow is melted, put in the oil, and draw the fire a little afterward, and allow the pan to stand about two hours. Light again the fire, and add about twenty gallons more of the ley. After the pan begins to boil, add now and then a little more ley, for the purpose of preventing the soap from boiling over: and this adding of ley is to be continued, until the soap is supposed to be about half boiled, when it will be time to try whether the soap have got too much or too little ley. This trial is called proving, and is necessary to be done several times during the operation, and previous to the finishing. The method of performing it is this: provide a piece of glazed Dutch delph, and also a clear clean knife; with the knife take up a piece of the soap from the pan, and if it turn whitish thereon, and fall from it in short pieces upon the delph, it is then to be concluded that too much ley has been put in; to rectify which, a little more oil must be added. On the contrary, if the soap want ley, it will fail from the knife in long ropy pieces; in consequence of which add some more ley. When, however, it happens to be brought to perfection, neither wanting more ley nor oil, but just in a right state, it will then be observed, when taken upon the knife, to stand the proper colour, not ropy, nor too white, but transparent. The fire may now be drawn, the soap being properly finished, and ought immediately to be cast into the barrels, firkins, &c. Remember always, after the second time the fire is lighted, to keep the soap boiling briskly till the pan is nearly ready, when it ought to boil slow until finishing, and ready to cast.

A Charge for Second Crown Soft Soap.

280 lbs. of tallow; 82 gallons of whale oil; and 140 gallons of ley.—Put in 100 gallons of ley with the tallow, and light the fire. When the tallow is melted add the oil, and draw the fire. Let all stand for two hours. Again light the fire, and add 20 gallons of ley. With this the boiling is to be continued, until the soap is about half finished, when ten gallons more of ley are to be added. During the remainder of the boiling, add, at different periods, the other ten gallons of ley, which will completely finish the soap. See *Fat.*

For *eau de luce*, Wiegleb directs, that in two drachms of the strongest alcohol be dissolved from six to ten drops of rectified oil of amber, and afterward one scruple of white soap; to this mixture is then to be poured an ounce of pure ammonia, and the whole well shaken together.

SOAP STONE.- See *Steatite.*

SODA. This is found to be a compound of oxygen and a metallic basis called sodium; but as it is found thus combined, and as it is only in this state of combination that it is of the smallest importance, it deserves to be specially noticed. It was formerly called mineral alkali, as it is found in mineral seams and crusts; also in very great abundance in certain lakes near Alexandria, in Egypt, in the dry season, being brought thither by the water which enters from the neighbouring country during the overflow of the Nile, and precipitated by the evaporation of the sun during the dry season. Barilla is the impure soda obtained by burning the Salsola soda, and other plants near the sea. Kelp is still more impure, containing only a small portion of pure alkali. It is obtained by burning sea-weed. For the purposes of commerce soda is obtained from common salt, or muriate of soda.

For the purposes of experiments, we may obtain very pure soda by boiling a solution of the pure carbonate in

half its weight of quick lime, and after subsidence decanting the clear ley, and after subsidence evaporating in a clean iron or silver vessel, till the liquid flows quietly like oil. It must then be poured out on a polished iron plate, and it will concrete into a hard cake, which must be broken to pieces and put up whilst hot into a phial, which must be well corked. If the carbonate of soda be impure, then, after employing the lime and evaporating, we must digest with alcohol, which will dissolve only the pure soda, and will leave the heterogeneous particles. Then, by distilling off the alcohol, the soda is obtained quite pure. The soda thus obtained is, however, only a hydrate of soda, being 100 soda and 28 water. If soda be exposed to the air, it becomes pasty, but it never melts into an oily liquid, like potass. In fact, by absorbing carbonic acid from the air, it become drier, and passes into an efflorescent carbonate. In order to distinguish soda from potash, we may use as a test the tartaric acid, which occasions precipitates with potash salts, but not with those of soda. Sulphate of soda is very soluble in water, but sulphate of potass is very sparingly so. Soda is employed in the manufacture of hard soap, and of plate and crown glass.

SODIUM. This is the metallic basis of soda, and it is obtained in the same manner as potassium, and has very similar properties. It is lighter than water, and if thrown upon it, it will swim on the surface, effervesce with great violence, and melt, rendering the water a solution of soda. There are different combinations of sodium and oxygen. One is the oxide, which is common soda, the other is the orange oxide, where the oxygen is in excess. There is said to be a sub-oxide, where there is less oxygen than in soda. Chlorine and sodium unite, and form common salt. Sodium combines with sulphur and phosphorus. Potassium and sodium readily combine, and the combination becomes fluid at a low temperature.

SOIL. The soil or earth in which vegetables grow, varies considerably in its composition, or in the proportions of the different earths of which it consists; and some plants are found to thrive best in one kind of soil, others in another. In cases where a barren soil is examined with a view to its improvement, it ought in all cases, if possible, to be compared with an extremely fertile soil in the same neighbourhood, and in a similar situation: the difference given by their analyses would indicate the methods of cultivation, and thus the plan of improvement would be founded upon accurate scientific principles. If the fertile soil contained a large quantity of sand, in proportion to the barren soil, the process of melioration would depend simply upon a supply of this substance; and the method would be equally simple with regard to soils deficient in clay or calcareous matter. In the application of clay, sand, loam, marle, or chalk to lands, there are no particular chemical principles to be observed: but when quicklime is used, great care must be taken that it is not obtained from the magnesian limestone; for in this case, as has been shown by Mr. Tennant, it is exceedingly injurious to land. The magnesian limestone may be distinguished from the common limestone by its greater hardness, and by the length of time that it requires for its solution in acids; and it may be analyzed by the process for carbonate of lime and magnesia. When the analytical comparison indicates an excess of vegetable matter as the cause of sterility, it may be destroyed by much pulverization and exposure to air, by paring and burning, or the agency of lately made quick lime. And the defect of animal and vegetable matter must be supplied by animal or vegetable manure. The general indications of fertility and barrenness, as found by chemical experiments, must necessarily differ in different climates and under different circumstances. The power of soils to absorb moisture, a principle essential to their productiveness, ought to be much greater in warm and dry countries than in cold and moist ones; and the quantity of fine aluminous earth they contain should be larger. Soils likewise that are situated on declivities ought to be more absorbent than those in the same climate on plains or in valleys. The productiveness of soils must likewise be influenced by the nature of the sub-soil, or the earthy or stony strata on which they rest; and this circumstance ought to be particularly

attended to, in considering their chemical nature, and the system of improvement. Thus, a sandy soil may owe its fertility to the power of the sub-soil to retain water: and an absorbent clayey soil may occasionally be prevented from being barren, in a moist climate, by the influence of a substratum of sand or gravel. Those soils that are most productive of corn, contain always certain proportions of aluminous or calcareous earth in a finely divided state, and a certain quantity of vegetable or animal matter. The quantity of calcareous earth is, however, very various, and in some cases exceedingly small. A very fertile corn soil from Ormiston, in East Lothian, afforded in a hundred parts, only eleven parts of mild calcareous earth; the finely divided clay amounted to forty-five parts. It lost nine in decomposed animal and vegetable matter, and four in water, and exhibited indications of a small quantity of phosphate of lime. This soil was of a very fine texture, and contained very few stones or vegetable fibres. It is not unlikely, that its fertility was in some measure connected with the phosphate, for this substance is found in wheat, oats, and barley, and may be a part of their food. A soil from the low lands of Somersetshire, celebrated for producing excellent crops of wheat and beans without manure, was found to consist of one-ninth of sand, chiefly silicious, and eight-ninths of calcareous marle tinged with iron, and containing about five parts in the hundred of vegetable matter. There was not detected in it any phosphate or sulphate of lime, so that its fertility must have depended principally upon its power of attracting principles of vegetable nourishment from water and the atmosphere. Mr. Tillet, in some experiments made on the composition of soils at Paris, found, that a soil composed of three-eighths of clay, two-eighths of river sand, and three-eighths of the parings of limestone, was very proper for wheat. In general, bulbous roots require a soil much more sandy, and less absorbent, than the grasses. A very good potatoe soil, from Varsel, in Cornwall, afforded seven-eights of silicious sand; and its absorbent power was so small, that 100 parts lost only two by drying at 400° Fahrenheit. Plants and trees, the roots of which are fibrous and hard, and capable of penetrating deep into the earth, will vegetate to advantage in almost all common soils that are moderately dry, and do not contain a very great excess of vegetable matter. The soil taken from a field at Sheffield-place, in Sussex, remarkable for producing flourishing oaks, was found to consist of six parts of sand, and one part of clay and finely divided matter. And 100 parts of the entire soil submitted to analysis, produced water 3, silex 54, alumina 28, carbonate of lime 3, oxide of iron 5, decomposing vegetable matter 4, loss 3. From the great difference of the causes that influence the productiveness of lands, it is obvious, that in the present state of science, no certain system can be devised for their improvement, independent of experiment; but there are few cases, in which the labour of analytical trials will not be amply repaid by the certainty with which they denote the best methods of melioration: and this will particularly happen when the defect of composition is found in the proportions of the primitive earths. In supplying animal or vegetable manure, a temporary food only is provided for plants, which is in all cases exhausted by means of a certain number of crops; but when a soil is rendered of the best possible constitution and texture with regard to its earthy parts, its fertility may be considered as permanently established. It becomes capable of attracting a very large portion of vegetable nourishment from the atmosphere, and of producing its crops with comparatively little labour and expense.

Analysis of Soils.—The instruments required for the analysis of soils are few, and but little expensive. They are a balance capable of containing a quarter of a pound of common soil, and capable of turning, when loaded with a grain; a set of weights from a quarter of a pound troy to a grain; a wire sieve, sufficiently coarse to admit a mustard-seed through its apertures; an Argand lamp and stand; some glass bottles; Hessian crucibles; porcelain, or queen's ware evaporating basins; a Wedgewood pestle and mortar; some filtres, made of half a sheet of blotting-paper, folded so as to contain a pint of

liquid, and greased at the edges; a bone knife, and an apparatus for collecting and measuring aeriform fluids. The chemical substances or reagents required for separating the constituent parts of the soil, have, for the most part, been mentioned before: they are muriatic acid (spirit of salt), sulphuric acid, pure volatile alkali dissolved in water, solution of prussiate of potash and iron, succinate of ammonia, soap ley, or solution of potassa, solutions of carbonate of ammonia, of muriate of ammonia, of neutral carbonate of potash, and nitrate of ammoniac. Soils, when collected, if they cannot be immediately examined, should be preserved in phials quite filled with them, and closed with ground glass stoppers. The quantity of soil most convenient for a perfect analysis, is from two to four hundred grains. It should be collected in dry weather, and exposed to the atmosphere till it becomes dry to the touch. It is of importance that the specific gravity of a soil should be known, as it affords an indication of the quantity of animal and vegetable matter it contains; these substances being always most abundant in the lighter soils. The other physical properties of soils should likewise be examined before the analysis is made, as they denote, to a certain extent, their composition, and serve as guides in directing the experiments. Thus, silicious soils are generally rough to the touch, and scratch glass when rubbed upon it; ferruginous soils are of a red or yellow colour; and calcareous soils are soft.

1. Soils, though as dry as they can be made by continued exposure to air, in all cases still contain a considerable quantity of water, which adheres with great obstinacy to the earths and animal and vegetable matter, and can only be driven off from them by a considerable degree of heat. The first process of analysis is, to free the given weight of soil from as much of this water as possible, without in other respects affecting its composition; and this may be done by heating it for ten or twelve minutes over an Argand lamp, in a basin of porcelain, to a temperature equal to 300 Fahrenheit; and if a thermometer is not used, the proper degree may be easily ascertained by keeping a piece of wood in contact with the bottom of the dish; as long as the colour of the wood remains unaltered, the heat is not too high; but when the wood begins to be charred, the process must be stopped. A small quantity of water will perhaps remain in the soil even after this operation, but it always affords useful comparative results; and if a higher temperature were employed, the vegetable or animal matter would undergo decomposition, and in consequence the experiment be wholly unsatisfactory. The loss of weight in the process should be carefully noted, and when in four hundred grains of soil it reaches as high as 50, the soil may be considered as in the greatest degree absorbent, and retentive of water, and will generally be found to contain much vegetable or animal matter, or a large proportion of aluminous earth. When the loss is only from 20 to 10, the land may be considered as only slightly absorbent and retentive, and silicious earth probably forms the greatest part of it.

2. None of the loose stones, gravel, or large vegetable fibres, should be divided from the pure soil till after the water is drawn off; for these bodies are themselves often highly absorbent and retentive, and in consequence influence the fertility of the land. The next process, however, after that of heating, should be their separation, which may be easily accomplished by the sieve, after the soil has been gently bruised in a mortar. The weights of the vegetable fibres or wood, and of the gravel and stones, should be separately noted down, and the nature of the last ascertained; if calcareous, they will effervesce with acids; if silicious, they will be sufficiently hard to scratch glass; and if of the common aluminous class of stones, they will be soft, easily cut with a knife, and incapable of effervescing with acids.

3. The greater number of soils, besides gravel and stones, contain larger or smaller proportions of sand of different degrees of fineness; and it is a necessary operation, the next in the process of analysis, to detach them from the parts in a state of more minute division, such as clay, loam, marle, vegetable and animal matter, and the matter soluble in water. This

may be effected in a way sufficiently accurate, by boiling the soil in three or four times its weight of water; and when the texture of the soil is broken down, and the water cool, by agitating the parts together, and then suffering them to rest. In this case, the coarse sand will generally separate in a minute, and the finer in two or three minutes, whilst the highly divided earthy, animal, or vegetable matter, will remain in a state of mechanical suspension for a much longer time; so that by pouring the water from the bottom of the vessel, after one, two, or three minutes, the sand will be principally separated from the other substances which, with the water containing them, must be poured into a filtre, and after the water has passed through, collected, dried, and weighed. The sand must likewise be weighed, and the respective quantities noted down. The water of lixiviation must be preserved, as it will be found to contain the saline and soluble animal or vegetable matters, if any exist in the soil.

4. By the process of washing and filtration, the soil is separated into two portions, the most important of which is generally the finely divided matter. A minute analysis of the sand is seldom or never necessary, and its nature may be detected in the same manner as that of the stones or gravel. It is always either siliceous sand or calcareous sand, or a mixture of both. If it consist wholly of carbonate of lime, it will be rapidly soluble in muriatic acid, with effervescence; but if it consist partly of this substance, and partly of siliceous matter, the respective quantities may be ascertained by weighing the residuum after the action of the acid, which must be applied till the mixture has acquired a sour taste, and has ceased to effervesce. This residuum is the siliceous part: it must be washed, dried, and heated strongly in a crucible; the difference between the weight of it and the weight of the whole, indicates the proportion of calcareous sand.

5. The finely divided matter of the soil is usually very compound in its nature; it sometimes contains all the four primitive earths of soils, as well as animal and vegetable matter; and to ascertain the proportions of these with tolerable accuracy is the most difficult part of the subject. The first process to be performed in this part of the analysis, is the exposure of the fine matter of the soil to the action of muriatic acid. This substance should be poured upon the earthy matter in an evaporating basin, in a quantity equal to twice the weight of the earthy matter; but diluted with double its volume of water. The mixture should be often stirred, and suffered to remain for an hour, or an hour and a half, before it is examined. If any carbonate of lime or of magnesia exist in the soil, they will have been dissolved in this time by the acid, which sometimes takes up likewise a little oxide of iron; but very seldom any alumina. The fluid should be passed through a filtre; the solid matter collected, washed with rain water, dried at a moderate heat, and weighed. Its loss will denote the quantity of solid matter taken up. The washings must be added to the solution, which if not sour to the taste, must be made so by the addition of fresh acid, when a little solution of prussiate of potassa and iron must be mixed with the whole. If a blue precipitate occurs, it denotes the presence of oxide of iron, and the solution of the prussiate must be dropped in till no farther effect is produced. To ascertain its quantity, it must be collected in the same manner as other solid precipitates, and heated red; the result is oxide of iron, which may be mixed with a little oxide of manganesum. Into the fluid freed from oxide of iron, a solution of neutralized carbonate of potash must be poured till all effervescence ceases in it, and till its taste and smell indicate a considerable excess of alkaline salt. The precipitate that falls down is carbonate of lime; it must be collected on the filtre, and dried at a heat below that of redness. The remaining fluid must be boiled for a quarter of an hour, when the magnesia, if any exist, will be precipitated from it, combined with carbonic acid, and its quantity is to be ascertained in the same manner as that of the carbonate of lime. If any minute proportion of alumina should, from peculiar circumstances, be dissolved by the acid, it will be found in the

precipitate with the carbonate of lime, and it may be separated from it by boiling it for a few minutes with soap lye, sufficient to cover the solid matter; this substance dissolves alumina, without acting upon carbonate of lime. Should the finely divided soil be sufficiently calcareous to effervesce very strongly with acids, a very simple method may be adopted for ascertaining the quantity of carbonate of lime, and one sufficiently accurate in all common cases. Carbonate of lime, in all its states, contains a determinate proportion of carbonic acid, *i. e.* nearly 43 per cent., so that when the quantity of this elastic fluid, given out by any soil during the solution of its calcareous matter in an acid is known, either in weight or measure, the quantity of carbonate of lime may be easily discovered. When the process by diminution of weight is employed, two parts of the acid, and one part of the matter of the soil, must be weighed in two separate bottles, and very slowly mixed together till the effervescence ceases; the difference between their weight before and after the experiment, denotes the quantity of carbonic acid lost; for every four grains and a quarter of which, ten grains of carbonate of lime must be estimated.

6. After the calcareous parts of the soil has been acted upon by muriatic acid, the next process is to ascertain the quantity of finely divided insoluble animal and vegetable matter that it contains. This may be done with sufficient precision, by strongly igniting it in a crucible over a common fire till no blackness remains in the mass. It should be often stirred with a metallic rod, so as to expose new surfaces continually to the air; the loss of weight that it undergoes denotes the quantity of the substance that it contains destructible by fire and air. It is not possible, without very refined and difficult experiments, to ascertain whether this substance is wholly animal or vegetable matter, or a mixture of both. When the smell emitted during the incineration is similar to that of burnt feathers, it is a certain indication of some substance either animal, or analogous to animal matter; and a copious blue flame at the time of ignition, almost always denotes a considerable proportion of vegetable matter. In cases when it is necessary that the experiment should be very quickly performed, the destruction of the decomposable substances may be assisted by the agency of nitrate of ammoniac, which at the time of ignition may be thrown gradually upon the heated mass in the quantity of twenty grains for every hundred of residual soil. It accelerates the dissipation of the animal and vegetable matter, which it causes to be converted into elastic fluids; and it is itself at the same time decomposed and lost.

7. The substances remaining after the destruction of the vegetable and animal matter, are generally minute particles of earthy matter, containing usually alumina and silica, with combined oxide of iron, or of manganesum.

To separate these from each other, the solid matter should be boiled for two or three hours with sulphuric acid, diluted with four times its weight of water; the quantity of the acid should be regulated by the quantity of solid residuum to be acted on, allowing for every hundred grains, two drachms, or one hundred and twenty grains of acid. The substance remaining after the action of the acid may be considered as siliceous; and it must be separated and its weight ascertained, after washing and drying in the usual manner. The alumina and the oxide of iron and manganesum (if any exist) are all dissolved by the sulphuric acid; they may be separated by succinate of ammonia, added to excess; which throws down the oxide of iron, and by soap lye, which will dissolve the alumina, but not the oxide of manganesum; the weights of the oxides ascertained after they have been heated to redness will denote their quantities. Should any magnesia and lime have escaped solution in the muriatic acid, they will be found in the sulphuric acid; this, however, is rarely the case; but the process for detecting them, and ascertaining their quantities, is the same in both instances. The method of analysis by sulphuric acid is sufficiently precise for all usual experiments; but if very great accuracy be an object, dry carbonate of potassa must be employed as the agent, and the residuum of the incineration (6)

must be heated red for half an hour, with four times its weight of this substance, in a crucible of silver, or of well baked porcelain. The mass obtained must be dissolved in muriatic acid, and the solution evaporated till it is nearly solid; distilled water must then be added, by which the oxide of iron and all the earths, except silica, will be dissolved in combination as muriates. The silica, after the usual process of lixiviation, must be heated red; the other substances may be separated in the same manner as from the muriatic and sulphuric solutions. This process is the one usually employed by chemical philosophers for the analysis of stones.

8. If any saline matter, or soluble vegetable or animal matter is suspected in the soil, it will be found in the water of lixiviation used for separating the sand.

This water must be evaporated to dryness in a proper dish, at a heat below its boiling point. If the solid matter obtained is of a brown colour and inflammable, it may be considered as partly vegetable extract. If its smell, when exposed to heat, be like that of burnt feathers, it contains animal or albuminous matter; if it be white, crystalline, and not destructible by heat, it may be considered as principally saline matter; the nature of which may be known by the tests described, p. 161.

9. Should sulphate or phosphate of lime be suspected in the entire soil, the detection of them requires a particular process upon it. A given weight of it, for instance, four hundred grains, must be heated red for half an hour in a crucible, mixed with one-third of powdered charcoal. The mixture must be boiled for a quarter of an hour, in a half pint of water, and the fluid collected through the filtre, and exposed for some days to the atmosphere in an open vessel. If any notable quantity of sulphate of lime (gypsum) existed in the soil, a white precipitate will gradually form in the fluid, and the weight of it will indicate the proportion. Phosphate of lime (if any exist) may be separated from the soil after the process for gypsum. Muriatic acid must be digested upon the soil, in quantity more than sufficient to saturate the soluble earths; the solution must be evaporated, and water poured upon the solid matter. This fluid will dissolve the compounds of earths with the muriatic acid, and leave the phosphate of lime untouched.

10. When the examination of a soil is completed, the products should be numerically arranged, and their quantities added together, and if they nearly equal the original quantity of soil, the analysis may be considered as accurate. It must, however, be noticed, that when phosphate or sulphate of lime are discovered by the independent process just described, (9), a correction must be made for the general process, by subtracting a sum equal to their weight from the quantity of carbonate of lime, obtained by precipitation from the muriatic acid.

In arranging the products, the form should be in the order of the experiments by which they were procured. Thus, sir H. Davy obtained from 400 grains of a good siliceous sandy soil from a hop garden near Tunbridge, Kent—

		Grs.
Of water of absorption -		19
Of loose stones and gravel principally siliceous		53
Of undecompounded vegetable fibres		14
Of fine siliceous sand - - -		212
Of minutely divided matter separated by agitation and filtration, and consisting of—		
Carbonate of lime	19	
Carbonate of magnesia -	3	
Matter destructible by heat, principally vegetable	15	
Silica - - -	21	
Alumina - - - -	13	
Oxide of iron - - -	5	
Soluble matter, principally common salt and vegetable extract	3	
Gypsum - - - -	2	
	—	81
Amount of all the products -		379
Loss - - - - - -		21

The loss in this analysis is not more than usually occurs, and it depends upon the impossibility of collecting the whole quantities of the different precipitates; and upon the presence of more moisture than is accounted for in the water of absorption, and

which is lost in the different processes. When the experimenter is become acquainted with the use of the differents, the properties of the reagents, and the relations between the external and chemical qualities of soils, he will seldom find it necessary to perform, in any one case, all the processes that have been described. When his soil, for instance, contains no notable proportion of calcareous matter, the action of the muriatic acid (7) may be omitted. In examining peat soils, he will principally have to attend to the operation by fire and air (8); and in the analysis of chalks and loams, he will often be able to omit the experiment by sulphuric acid (9). A good turnip soil from Holkham, Norfolk, afforded me eight parts out of nine siliceous sand; and the finely divided matter consisted—

Of carbonate of lime	-	63
— Silica	-	15
— alumina	-	11
— oxide of iron	-	3

SOLDERS, and SOLDERING. Solders consist merely of simple or mixed metals, by which alone metallic bodies can be firmly united with each other. In this respect it is a general rule, that the solder should always be easier of fusion than the metal intended to be soldered by it; next to this, care must also be taken, that the solder be, as far as is possible, of the same colour with the metal that is to be soldered. For the simple solders, each of the metals may be used according to the nature of that which is to be soldered. For fine steel, copper, and brass work, gold and silver may be employed. In the large way, however, iron is soldered with copper, and copper and brass with tin. The most usual solders are the compound, which are distinguished into two principal classes, viz. hard and soft solders. The hard solders are ductile, will bear hammering, and are commonly prepared of the same metal with that which is to be soldered, with the addition of some other, by which a greater degree of fusibility is obtained, though the addition is not always required to be itself easier of fusion. Under this head comes the hard solder for gold, which is prepared from gold and silver, or gold and copper, or gold, silver and copper. The hard solder for silver is prepared from equal parts of silver and brass, but made easier of fusion by the admixture of a sixteenth part of zinc. The hard solder for brass is obtained from brass mixed with a sixth, or an eighth, or even one half of zinc, which may also be used for the hard solder of copper. It is sold in the shops in a granulated form, under the name of spelter-solder. The soft solders melt easily, but are partly brittle, and therefore cannot be hammered. Of this kind are the following mixtures:—tin and lead in equal parts; of still easier fusion is that consisting of bismuth, tin and lead, equal parts; 1 or 2 parts of bismuth of tin and lead, each 1 part. In the operation of soldering, the surfaces of the metal intended to be joined must be made very clean, and applied to each other. It is usual to secure them by a ligature of iron wire, or other similar contrivance. The solder is laid upon the joint, together with sal ammoniac or borax, or common glass, according to the degree of heat intended. These additions defend the metal from oxidation. Glaziers use resin; and pitch is sometimes employed. Tin-foil applied between the joints of fine brass work, first wetted with a strong solution of sal ammoniac, makes an excellent juncture, care being taken to avoid too much heat.

SOLIDS and SOLIDITY. See *Caloric* and *Crystallization.*

SOLUTION. See *Salt, Crystallization*, and *Attraction.*

SOMMITE. nepheline.

SORBATES, compounds of sorbic, or malic acid, with the salifiable bases.

SORBIC ACID, an acid supposed to be found in the sorbus aucuparia or mountain ash. The malic acid and sorbic acid are considered to be the same.

SORY, sulphate of iron.

SPAR (Fluor). See *Fluor.*

SPAR PONDEROUS. See *Heavy Spar.*

SPARRY ANHYDRITE, or CUBE-SPAR, a species of prismatic gypsum, consisting, according to Klaproth, of sulphuric acid 55, lime 41·75, muriate of soda 1.

SPARRY IRON, carbonate of iron, consisting, according to Klaproth, of 36 carbonic acid, 57·5 oxide

of iron, oxide of manganese 3·5, lime 1·25.

SPECIFIC GRAVITY, the relative weight of equal portions of different kinds of matter. For fluids and solids, the common standard of reference is pure distilled water at 62° Fahrenheit, of which a cubic foot will weigh 1000 ounces. The specific gravity of water is called 1, or 1000.

TABLE OF THE SPECIFIC GRAVITIES OF DIFFERENT BODIES.*

Metals.

Antimony, crude	4·064
——— glass of	4·946
——— molten	6·702
Arsenic, glass of, natural	3·594
——— molten	5·763
——— native orpiment	5·452
Bismuth, molten	9·823
——— native	9·020
——— ore of, in plumes	4·371
Brass, cast, not hammered	8·396
——— ditto, wire-drawn	8·544
——— cast, common	7·824
Cobalt, molten	7·812
——— blue glass of	2·441
Copper, not hammered	7·788
——— the same wire-drawn	8·878
——— ore of soft copper, or natural verdigrease	3·572
Gold, pure, or 24 carats, melted, but not hammered	19·258
——— the same hammered	19·362
——— Parisian standard, 22 carats, not hammered	17·486
——— the same hammered	17·589
——— guinea of Geo. II.	17·150
——— guinea of Geo. III.	17·629
——— Spanish gold coin	17·655
——— Holland ducats	19·352
——— trinket standard, 20 carats, not hammered	15·709
——— the same hammered	15·775
Iron, cast	7·207
——— bar, either hardened or not	7·788
Steel, neither tempered nor hardened	7·833
——— hardened, but not tempered	7·840
——— tempered and hardened	7·818
——— ditto, not hardened	7·816
Iron, ore prismatic	7·351
——— ditto, specular	5·218
——— ditto, lenticular	5·012
Lead, molten	11·352
——— ore of, cubic	7·587
——— ditto, horned	6·072
——— ore of black lead	6·745
——— ditto, white lead	4·059
Lead, ore of, vitreous	6·558
——— ditto, red lead	6·027
——— ditto, saturnite	5·925
Manganese, striated	4·756
——— metallic	6·850
Molybdena	4·738
Mercury, solid or congealed	15·632
——— fluent	13·568
——— natural oxide of	9·230
——— precipitate per se	10·871
——— precipitate, red	8·399
——— brown cinnabar	10·218
——— red cinnabar	6·902
Nickel, molten	7·807
——— ore of, called kupfer-nickel of Saxe	6·648
——— kupfernickel of Bohemia	6·607
Platina, crude, in grains	15·602
——— purified, not hammered	19·500
——— purified, hammered	20·337
——— ditto, wire-drawn	21·042
——— ditto, rolled	22·069
Silver, virgin, 12 deniers, fine, not hammered	10·744
——— ditto, hammered	10·511
——— Paris standard	10·175
——— shilling of Geo. II.	10·000
——— shilling of Geo. III.	10·534
——— French coin	10·408
Tin, pure Cornish, melted, and not hardened	7·291
——— the same hardened	7·299
——— of Malacca, not hardened	7·296
——— the same hardened	7·307
——— ore of, red	6·935
——— ore of, black	6·901
——— ore of, white	6·008
Tungsten	6·066
Uranium	6·440
Wolfram	7·119
Zinc, molten	7·191

Precious Stones.

Beryl, or aqua-marine, oriental	3·549
——— ditto, occidental	2·723
Chrysolite, of the jewellers	2·782
——— of Brazil	2·692
Crystal, pure rock of Madagascar	2·653
——— of Brazil	2·653
——— European	2·655
——— rose-coloured	2·670
——— yellow	2·654
——— violet, or amethyst	2·654
——— white amethyst	2·651
——— Carthagenian	2·657
——— black	2·654
Diamond, white oriental	3·521

Diamond, rose-coloured, oriental	3·531
——— orange, ditto	3·550
——— green, ditto	3·524
——— blue, ditto	3·525
——— Brazilian	3·444
——— yellow	3·519
Emerald of Peru	2·775
Garnet of Bohemia	4·189
——— of Syria	4·000
——— dodecaedral	4·063
——— volcanic, 24 faces	2·468
Girasol	4·000
Hyacinth, common	3·687
Jargon of Ceylon	4·416
Quartz, crystallized	2·655
——— in the mass	2·647
——— brown crystallized	2·647
——— fragile	2·640
——— milky	2·652
——— fat, or greasy	2·646
Ruby, oriental	4·283
——— spinell	3·760
——— balias	3·646
——— Brazilian	3·531
Sapphire, oriental	3·994
——— ditto, white	3·991
——— of Puys	4·077
——— Brazilian	3·131
Spar, white sparkling	2·595
——— red, ditto	2·438
——— green, ditto	2·704
——— blue sparkling	2·693
——— green and white, ditto	3·105
——— transparent, ditto	2·564
——— adamantine	3·873
Topaz, oriental	4·011
——— pistachio, ditto	4·061
——— Brazilian	3·536
——— of Saxe	3·564
——— white, ditto	3·554
——— vermilion	4·230
Siliceous Stones.	
Agate, oriental	2·590
——— onyx	2·638
——— cloudy	2·625
——— speckled	2·607
——— veined	2·667
——— stained	2·632
Chalcedony, common	2·616
——— transparent	2·664
——— veined	2·606
——— reddish	2·665
——— blueish	2·581
——— onyx	2·615
Cornelian, pale	2·630
——— speckled	2·612
——— veined	2·623
——— onyx	2·623
——— stalactite	2·598
——— simple	2·613
Corundum	3·000
Flint, white	2·594
——— black	2·582
——— veined	2·612
——— Egyptian	2·565
Jade, white	2·950
——— green	2·966
——— olive	2·983
Jasper, clear green	2·539
——— brownish green	2·681
——— red	2·661
——— brown	2·691
——— yellow	2·710
——— violet	2·711
——— cloudy	2·735
——— veined	2·696
——— onyx	2·816
——— red and yellow	2·750
——— bloody	2·628
Onyx	2·376
Opal	2·114
Pearl, virgin, oriental	2·684
Pebble, onyx	2·664
——— of Rennes	2·654
——— English	2·609
——— veined	2·612
——— stained	2·587
Prasium	2·581
Sardonyx, pure	2·603
——— pale	2·606
——— speckled	2·621
——— veined	2·595
——— onyx	2·595
——— blackish	2·628
Schorl, black prismatic hexaëdral	3·364
——— octaedral	3·226
——— tourmaline of Ceylon	3·054
——— antique basaltes	2·923
——— Brazilian emerald	3·156
——— cruciform	3·286
Stone, paving	2·416
——— cutler's	2·111
——— grind	2·134
Various Stones, Earths, &c.	
Alabaster, oriental white	2·730
——— ditto, semi-transparent	2·762
——— yellow	2·699
——— stained brown	2·744
——— veined	2·691
——— of Piedmont	2·693
——— of Malta	2·699
——— Spanish saline	2·713
——— of Valencia	2·638
——— of Malaga	2·876
Alumine	2·000
Amber, yellow transparent	1·078
Ambergris	·926
Amianthus, long	·909
——— short	2·313

Asbestos, ripe - - -	2·578
——— starry - - -	3·073
Barytes - - - - -	4·200
Basaltes from Giant's Causeway	2·864
Bitumen, of Judea - -	1·104
Brick - - - - - -	2·000
Chalk, Spanish - - -	2·790
——— coarse Briançon -	2·727
——— British - - -	2·784
Fluor spar - - - -	3·180
Gypsum, opaque -	2·168
——— semi-transparent -	2·306
——— fine ditto - -	2·274
——— rhomboidal - -	2·311
——— ditto, 10 faces -	2·312
——— cuneiform crystallized	2·306
Glass, green - - -	2·642
—— white - - - -	2·892
—— bottle - - - -	2·733
—— Leith crystal - -	3·189
—— fluid - - - -	3·329
Granite, red Egyptian - -	2·664
——— of Balbeck - -	3·506
Hone, white razor - -	2·876
Lapis nephriticus - -	2·894
—— lazuli - - - -	3·054
—— hæmatites - - -	4·360
—— calaminaris - -	5·000
—— Judaicus - - -	2·520
—— manati - - -	2·270
Lime, pure - - - -	2·300
Limestone - - - -	3·179
——— white flour - -	3·156
——— green - - -	3·182
Magnesia - - - - -	2·300
Marble, green Campanian -	2·742
——— red - - - -	2·724
——— white Carrara -	2·717
——— white Parian - -	2·838
——— Pyrenean - -	2·726
——— black Biscayan -	2·695
——— Brocatelle - -	2·650
——— Castilian - -	2·700
——— Valencian - -	2·710
——— white Grenadan -	2·705
——— Siennian - -	2·678
——— Roman violet -	2·755
——— African -	2·708
——— violet Italian -	2·858
——— Norwegian -	2·728
——— Siberian -	2·718
——— green Egyptian	2·668
——— Swiss - - -	2·711
——— French - -	2·649
Obsidian stone - - -	2·348
Peat, hard - - -	1·329
Ponderous spar - - -	4·474
Porcelain, Sevres - - -	2·146
——— Limoges - -	2·341
——— China - -	2·385
Porphyry, red - -	2·765
Porphyry, green - - -	2·676
——— red, from Dauphiny	2·793
——— red, from Cordova	2·754
——— green, from ditto -	2·728
Pyrytes, coppery - - -	4·954
——— ferruginous cubic -	3·900
——— ditto round - -	4·101
——— ditto of St. Domingo	3·440
Serpentine, opaque, green Italian	2·430
——— ditto, veined black and olive - - - -	2·594
——— ditto, red and black	2·627
——— semi-transparent grained - - -	2·586
——— ditto, fibrous -	3·000
——— ditto, from Dauphiny	2·669
Silex - - - - - -	2·650
Slate, common - - -	2·672
—— new - - - -	2·854
—— black stone - -	2·185
—— fresh polished - -	2·766
Stalactite, transparent -	2·324
——— opaque - -	2·478
Stone, pumice - - -	·915
——— prismatic basaltes -	2·722
——— touch - - -	2·415
——— Siberian blue - -	2·945
——— oriental ditto - -	2·771
——— common - - -	2·520
——— Bristol - - -	2·510
——— Burford - -	2·049
——— Portland - -	2·496
——— rag - - - -	2·470
——— rotten - - -	1·981
——— hard paving - -	2·460
——— mill - - - -	2·500
——— elicard, from Brachet	2·357
——— ditto, from Ouchain -	2·2[illegible]1
——— Notre Dame - -	2·378
——— St. Maur - - -	2·034
——— St Cloud - -	2·2[illegible]1
Strontian - - -	3·70[illegible]
Sulphur, native - - -	2·033
——— molten - - -	1·991
Talc, of Muscovy - -	2·792
—— black crayon - -	2·080
—— ditto German - -	2·216
—— yellow - - -	2·655
—— black - - -	2·900
—— white - - -	2·704
Zircon - - - - -	4·[illegible]
Liquors, Oils, &c.	
Acid, sulphuric - - -	1·841
—— ditto, highly concentrated	2·125
—— nitric - - - -	1·271
—— ditto, highly concentrated	1·580
—— muriatic - - -	1·1[illegible]4
—— red acetous - -	1·025
—— white acetous - -	1·014
—— distilled ditto - -	1·010
—— fluoric - - -	1·500

Acid, acetic - - -	1·063
—— phosphoric - -	1·558
—— formic - - -	·994
Alcohol, commercial - -	·837
——— highly rectified -	·829
——— mixed with water	
15-16ths alcohol -	·853
14-16ths ditto -	·867
13-16ths ditto -	·882
12-16ths ditto -	·895
11-16ths ditto -	·904
10-16ths ditto -	·920
9-16ths ditto -	·932
8-16ths ditto -	·943
7-16ths ditto -	·952
6-16ths ditto -	·960
5-16ths ditto -	·967
4-16ths ditto -	·973
3-16ths ditto -	·979
2-16ths ditto -	·985
1-16th ditto -	·997
Ammonia, liquid - -	·897
Beer, pale - -	1·023
—— brown - - -	1·038
Cyder - - -	1·018
Ether, sulphuric - - -	·739
——— nitric - - -	·909
——— muriatic - -	·730
——— acetic - -	·860
Milk, woman - - -	1·020
—— cow's - - -	1·032
—— ass's - - -	1·035
—— ewe's - - -	1·041
—— goat's - - -	1·035
—— mare's - - -	1·034
—— cow's clarified - -	1·019
Naphtha, Persian - -	·753
——— ditto distilled from coals in London - - -	·817
Oil, essential of turpentine	·870
——— of lavender -	·894
——— of cloves -	1·036
——— of cinnamon -	1·044
—— of olives - - -	·915
—— of sweet almonds -	·917
—— of filberts - - -	·916
—— linseed - - -	·940
—— of walnuts - - -	·923
—— of whale - - -	·923
—— of hempseed - -	·926
—— of poppies - - -	·924
—— rapeseed - - -	·919
Spirit of wine. See Alcohol.	
Turpentine, liquid - -	·991
Urine, human - - -	1·011
Water, rain - - -	1·000
—— distilled - - -	1·000
—— sea (average) -	1·026
—— of Dead Sea - -	1·240
Wine, Burgundy - -	·992
—— Bordeaux - -	·994
Wine, Madeira - -	·938
—— Port - - -	·997
—— Canary - - -	1·033

Resins, Gums and Animal Substances, &c.

Aloes, socotrine - -	1·380
—— hepatic - - -	1·359
Assafoetida - - -	1·328
Bees'-wax, yellow - -	·965
——— white - -	·969
Bone of an ox - - -	1·656
Butter - - - -	·942
Calculus, human - -	1·700
——— ditto - - -	1·210
——— ditto - - -	1·431
Camphor - - - -	·989
Copal, opaque - - -	1·140
—— Madagascar - -	1·060
—— Chinese - - -	1·063
Crassamentum, of the human blood - - -	1·126
Dragon's blood - - -	1·205
Elemi - - - -	1·018
Fat, beef - - - -	·923
—— hog's - - - -	·937
Fat, mutton - - -	·924
—— veal - - - -	·934
Galbanum - - - -	1·212
Gamboge - - - -	1·222
Gum, ammoniac - - -	1·207
—— Arabic - - -	1·452
—— euphorbia - - -	1·124
—— seraphic - - -	1·201
—— tragacanth - -	1·316
—— bdellium - - -	1·372
—— scammony of Smyrna	1·274
—— ditto of Aleppo - -	1·235
Gunpowder, shaken - -	·932
——— in a loose heap	·836
——— solid - -	1·745
Honey - - - -	1·450
Indigo - - - -	·769
Ivory - - - -	1·826
Juice of liquorice - -	1·722
—— of acacia - - -	1·515
Labdanum - - -	1·186
Lard - - - - -	·948
Mastic - - - -	1·074
Myrrh - - - -	1·360
Opium - - - -	1·336
Phosphorus - - -	1·714
Serum of human blood -	1·030
Spermaceti - - -	·943
Storax - - - -	1·110
Tallow - - - -	·942
Terra Japonica - -	1·398
Wax, shoemaker's - -	·897

Woods.

Alder - - - -	·800
Apple-tree - - - -	·793
Ash, the trunk - - -	·845

Bay-tree	·822
Beech	·852
Box, French	·912
—— Dutch	1·328
—— Brazilian red	1·031
Campechy wood	·913
Cedar, wild	·596
——— Palestine	·613
——— Indian	1·315
——— American	·561
Citron	·726
Cocoa-wood	1·040
Cherry-tree	·715
Cork	·240
Cypress, Spanish	·644
Ebony, American	·331
——— Indian	1·209
Elder-tree	·695
Elm, trunk of	·671
Filbert-tree	·600
Fir, male	·550
—— female	·498
Hazel	·600
Jasmin, Spanish	·770
Juniper-tree	·556
Lemon-tree	·703
Lignum-vitæ	1·333
Linden-tree	·604
Logwood.—See Campechy.	
Mastich-tree	·849
Mahogany	1·063
Maple	·750
Medlar	·944
Mulberry, Spanish	·897
Oak, heart of, 60 years old	1·170
—— dry oak	·925
Olive-tree	·927
Orange-tree	·705
Pear-tree	·661
Pomegranate-tree	1·354
Poplar	·383
——— white, Spanish	·529
Plum-tree	·785
Quince-tree	·705
Sassafras	·482
Vine	1·327
Walnut	·671
Willow	·585
Yew, Dutch	·788
—— Spanish	·897
Gases.	
Atmospheric air (being)	1·0000
Vapour of hydriodic ether	5·4749
———— oil of turpentine	5·0130
Hydriotic acid gas	4·4430
Fluo-silicic acid gas	3·5735
Vapour of Sulphuret of carbon	2·6447
———— sulphuric ether	2·5860
Chlorine	2·4700
Fluo-boric gas	2·3709
Vapour of muriatic ether	2·2190
Sulphurous acid gas	2·1920
Cyanogen	1·8064
Vapour of absolute alcohol	1·6133
Nitrous oxide	1·5204
Carbonic acid	1·5196
Muriatic acid gas	1·2474
Sulphuretted hydrogen	1·1912
Oxygen gas	1·1036
Nitrous gas	1·0388
Olefiant gas	0·9784
Azote, or nitrogen gas	0·9691
Oxide of carbon	0·9569
Hydro-cyanic vapour	0·9476
Phosphuretted hydrogen	0·8700
Steam of water	0·6235
Ammoniacal gas	0·5967
Carburetted hydrogen	0·5550
Arseniated hydrogen	0·5290
Hydrogen gas	0·0732

In this table the weights and specific gravities of the principal gases are given, as they correspond to a state of the barometer and thermometer which may be chosen for a medium. The specific gravity of any one gas to that of another, will not conform to exactly the same ratio, under different degrees of heat and other pressures of the atmosphere; because the various expansions by no means follow the same law. These numbers being the weight of a cubic foot, or 1728 cubic inches, of each of the bodies, in avoirdupois ounces; by proportion, the quantity in any other weight, or the weight of any other quantity, may be readily known.

For example.—Required the contents of an irregular block of millstone, which weighs 1 cwt., or 112 lb., or 1792 ounces. Here, as 8500 : 1792 : : 1728 : 1228; cubic inches the contents.

Ex. 2.—To find the weight of a block of granite, whose length is 63 feet, and breadth and thickness, each 12 feet; being the dimensions of one of the stones of granite in the walls of Balbec. Here, 63 × 12 × 12 = 9072 feet is the contents of the stone; therefore, as 1 : 9072 : : 3500 oz. · 31752000 ounces, or 885 tons, 18 cwt. the weight of the stone.

To ascertain the purity of tin, &c., pewterers, and other dealers in tin, cast a bullet of pure tin, and another of the mixture of tin and lead, which they want to examine, in the same mould; and the more the bullet of the mixture exceeds the

bullet of pure tin in weight, the more lead they conclude it contains.

SPECULUM. Mr. Edwards affirms that different kinds of copper require different doses of tin to produce the most perfect whiteness. If the dose of tin be too small, which is the fault most easily remedied, the composition will be yellowish; if it be too great, the composition will be of a grey-blue colour, and dull appearance. He casts the speculum in sand, with the face downwards; takes it out while red-hot, and places it in hot wood ashes to cool; without which precaution it would break in cooling. Mr. Little recommends the following proportions:—32 parts of the best bar copper, 4 parts of the brass of pin-wire, 16½ of tin, and 1¼ of arsenic. Silver he rejects, as it has an extraordinary effect of softening the metal; and he found, that the compound was not susceptible of the highest polish, unless it was extremely brittle. He first melts the brass, and adds to it about an equal weight of tin. When this mixture is cold, he puts it into the copper previously fused with black flux, adds next the remainder of the tin, and lastly the arsenic. This mixture he granulates, by pouring into cold water, as Mr. Edwards did, and fuses it a second time for casting.

SPERMACETI, a whitish unctuous substance, obtained chiefly from the brains of a whale, called physeter macrocephalus.

SPHENE, an ore of Titanium.

SPHRAGIDE, Lemnian earth,—which see.

SPINEL, a sub species of corrundum. Its constituents are, alumina 82·47, magnesia 8·78, chromic acid 6·18.

SPIRIT OF MINDERERUS, a solution of acetate of ammonia, made by adding concrete carbonate of ammonia to distilled vinegar, till saturation take place.

SPIRIT, PYRO-ACETIC, is a light volatile spirit, produced by exposing dry acetates to heat in a retort. It is limpid and colourless.

SPIRIT OF SAL AMMONIAC, water of ammonia.

SPIRIT OF SALT, muriatic acid.

SPIRIT OF WINE, alcohol.

SPODUMENE, a spar, consisting of silica 64·4, alumina 24·4, lime 3, potass 5, oxide of iron 2·2.

SPONGE. A soft, light, very porous, and compressible substance, readily imbibing water, and distending thereby. It is found adhering to rocks, particularly in the Mediterranean Sea, about the islands of the Archipelago. It was formerly supposed to be a vegetable production, but is now classed among the zoophytes; and analyzed, it yields the same principles with animal substances in general.

SPONTANEOUS COMBUSTION. Many vegetable substances, highly dried and heaped together, will heat, scorch, and at last burst into a flame. Of these, the most remarkable is a mixture of the expressed oil of the farinaceous seeds, as rape or linseed oil, with almost any dry vegetable fibre, such as hemp, cotton, matting, &c. and still more so, if also united with lamp-black, or any other carbonaceous substance. These mixtures if kept for a time undisturbed, in close bundles, and in a warm temperature, even in small quantities, will often heat, and burn with a smothered fire for some hours; and if air be admitted freely, will then burst into flame. To this, without doubt, may be attributed several accidental conflagrations in storehouses, and places where quantities of these substances are kept. Indeed this has been proved by many experiments. The most important of these were made by Mr. George, and a committee of the Royal Academy at Petersburgh, in the year 1781, in consequence of the destruction, by fire, of a frigate in the harbour of Cronstadt, the conflagration of a large hemp magazine, in the same place in the same year, and a slight fire on board another frigate, in the same port, in the following year. These accidents led to a very strict examination of the subject, by the Russian government; when it came out, that at the time of the second accident, several parcels of matting tied with packthread, in which the soot of burnt fir-wood had been mixed with oil for painting the ship, had been lying some time on the floor of the cabin, whence the fire broke out. In consequence of this important discovery, forty pounds of

fir-wood soot were well soaked in about thirty-five pounds of hemp oil varnish, and the whole was wrapped up in a mat, and put in a close cabin. In about sixteen hours, it was observed to give out a smoke, which rapidly increased, and when the door was opened, and the air freely admitted, the whole burst into a flame. Three pounds of fir-black were mixed with five pounds of hemp-oil varnish, and the whole bound up in linen, and shut up in a chest. In sixteen hours, it emitted a very nauseous putrid smell and steam; and two hours afterward, it was actually on fire, and burnt to ashes. In another experiment, the same occurrences took place, but not till the end of forty-one hours after the mixture had been made; and in these and many similar experiments, they all succeeded better, and kindled sooner, in dry, than in rainy weather. Chimney soot used instead of lamp-black did not answer, nor was any effect produced, when oil of turpentine was substituted for the hemp or rape-oil. In general, it was found, that the combination took place more readily with the coarser and more unctuous fir-black, than with the finer sorts; but the proportions of the black to the oil did not appear to be of any great moment. Sometimes, in wet weather, these mixtures only became hot for some hours, and then cooled again, without actually taking fire. In all these cases, the soot or black, was from wood and not coal. The presence of lamp-black, or any other dry carbonous matter, is not necessary however; for, spontaneous inflammation will take place in hemp or cotton, simply soaked in any of these expressed oils, when in considerable quantity, or under circumstances favourable to this process; as in hot weather, or when closely shut up. An accident of this sort happened at Gainsborough, in Lincolnshire, in July, 1794, with a bale of yarn of 120lb., accidentally soaked in rape oil; which, after remaining in a warehouse for several days, began to smoke, to emit a most nauseous smell, and finally to burst out into a most violent flame. A similar accident, with a small quantity of the same materials, happened at Bombay. A bottle of linseed oil had been left standing on a chest; this had been thrown down by accident in the night, the oil ran into a chest which contained some coarse cotton cloth, and in the morning the cloth was found scorching hot, and reduced nearly to tinder, the wood of the chest also was charred on the inside. On subsequent trial, a piece of the same cloth was soaked in oil, shut up in a box, and in no longer time than three hours, it was found scorching hot; and on opening the cloth it burst into flame. Similar to this, is the spontaneous combustion of wool, or woollen yarn, which has occasionally happened when large quantities have been kept heaped up in rooms little aired, and in hot weather. The oil with which wool is dressed, which is generally rape-oil, appears the chief agent in this combustion. Even high dried, oily, or farinaceous matter of any kind, will alone take fire, when placed in circumstances very favourable to this process. Rye flour roasted till half parched, and of the colour of coffee, and wrapped up in a linen cloth, has been found to heat violently and to destroy the cloth. Wheat flour when heated in large quantities, and highly dried, has been known to take fire in hot weather, causing accidents in granaries and bakers' shops. An accident of this kind is related by Count Morrozzo, in the Memoirs of the Turin Academy, to have happened at a flour warehouse at Turin, containing about three hundred sacks of flour. It began by a violent explosion, on a lamp being brought into the warehouse, and the whole was soon after in flames. Charcoal alone also has been known to take fire in powder mills, when quantities of it in powder have been kept for some time closely packed.

Another, and totally different species of spontaneous combustion, is that which occurs during the oxygenation or vitriolization of pyrites, or sulphurets of iron, copper, &c. A most curious, and, if not well authenticated, a scarcely credible species of spontaneous inflammation, is that in a few rare instances, known to occur in the human body. It is not quite certain indeed, whether the first inflammation has been quite sponta-

neous, or caused by the approach of a lighted substance; but in these melancholy accidents, the body of the unfortunate sufferer has been brought to a state of such high combustibility, that the flame once kindled, has gone on without other fuel, to the entire destruction of every part, (the bones and extremities excepted) and as it appears, has been attended with actual flame, of a lambent faint light. This change is the more remarkable, as the human body, in all its usual states, both of health and disease, is scarcely at all of itself combustible, and cannot be reduced to ashes without the assistance of a very large pile of faggots, or other fuel; as universal experience, in the very ancient mode of sepulture, and the history of martyrdoms, abundantly shews. Cases of this human combustion on record, have occurred in different countries. Two of them, well authenticated, are recorded in the Philosophical Transactions, and occurred in England; and a few others in Italy, France, and elsewhere. In all but one, the subjects of them have been females rather advanced in life, of indolent habits, and apparently much addicted to spirituous liquors. The accident has generally been detected by the penetrating fœtid smell of burning and sooty films, which have spread to a great distance; and the sufferers have, in every instance, been discovered dead, and with the body more or less completely burnt up, leaving in the burnt parts only, an oily, crumbly, sooty, and extremely fœtid, matter. Another circumstance in which these cases all agree, is the comparative weakness of the heat produced by this combustion, notwithstanding the very complete disorganization of the body itself, so that the furniture of the room, wooden chairs, &c. found within the reach of the burning body, were in many instances absolutely unhurt, and in others only scorched; the heat not having been strong enough to set them on fire. It is impossible to give an adequate reason for this remarkable change; nor does it seem before the very time of the accident to have produced any very sensible alteration in the appearance and functions of the body, which is certainly a most astonishing circumstance. With regard to the effect which the use of ardent spirits is supposed to have in this case, it is impossible not to imagine that this cause may contribute largely to such a change; but the instances of the abuse of spirits are so innumerable, and those of this surprising combustion are so extremely rare, that very little satisfaction can be obtained from this explanation. Hydrogen gas enters largely into all animal, vegetable, and many mineral compositions. Hence, it is frequently set at liberty by fermentation or spontaneous decomposition in bogs and marshes; when from electricity, or some other accidental cause, it is often set on fire. This phenomenon has been observed in almost all parts of the world. In Persia it is converted into a pious fraud by the priesthood, who, by means of hollowed reeds, convey the carburretted hydrogen gas into one of their temples, which has been purposely built upon ground abounding in bitumen, naphtha, and other inflammable substances. As the Persians have always been worshippers of fire, the imposition is a happy one, for in this temple, they are continually feasted with a view of their Deity. At Moulton, near Northampton, in the forenoon of September, 11th, 1810, a fire broke out in an ash-spinney. Mr. Marsh, the proprietor immediately went to the spot with some friends, and found the fire issuing from the earth in many places, and in a short time it would have communicated to a gorse cover, had it not been for the timely assistance of several persons whom curiosity had brought to witness this extraordinary phenomenon. As there was some lightning during the morning, it was imagined a fire-ball had been the cause, but it was generally supposed to be occasioned by the excessive dryness of the ground, which had been a bog, recently drained for planting; and that the extreme heat of the sun had caused it to ignite.

STALACTITES. These are found suspended from vaults, being formed by the oozing of water charged with calcareous particles, and gradually evaporating, leaving those particles behind.

STARCH. This is a white, insipid, combustible substance, insoluble in cold water, but forming a jelly

with boiling water. It exists chiefly in the white and brittle parts of vegetables, particularly in tuberose roots, and the seeds of the gramineous plants. It may be extracted by pounding these parts, and agitating them in cold water; when the parenchyma, or fibrous parts, will first subside; and these being removed, a fine white powder, diffused through the water, will gradually subside, which is the starch. Or the pounded or grated substance, as the roots of arum, potatoes, acorns, or horse-chestnuts, for instance, may be put into a hair-sieve and the starch washed through with cold water, leaving the grosser matters behind. Farinaceous seeds may be ground and treated in a similar manner. Oily seeds require to have the oil expressed from them before the farina is extracted. If starch be subjected to distillation, it gives out water impregnated with empyreumatic acetous acid, a little red or brown oil, a great deal of carbonic acid, and carburetted hydrogen gas. Its coal is bulky, easily burned, and leaves a very small quantity of potash and phosphate of lime. If when diffused in water it be exposed to a heat of 60 deg. F., or upwards, it will ferment, and turn sour; but much more so if it be not freed from the gluten, extract, and colouring-matter. Thus, in starch-making, the farina ferments and becomes sour, but the starch that does not undergo fermentation, is rendered the more pure by this process. Some water already soured is mixed with the flour and water, which regulates the fermentation, and prevents the mixture from becoming putrid; and in this state it is left about ten days in summer and fifteen in winter, before the scum is removed, and the water poured off. The starch is then washed out from the bran, and dried, first in the open air, and finally in an oven. With boiling water starch forms a nearly transparent mucilage, emitting a peculiar smell, neither disagreeable nor very powerful. This mucilage may be dried, and will then be semi-transparent, and much resembling gum, all the products of which it affords. When dissolved, it is much more easily digested and nutritious than before it has undergone this operation. Both acids and alkalis combined with water dissolve it. It separates the oxides of several metals from their solutions, and takes oxygen from many of them. It is found naturally combined with all the immediate principles of vegetables, and may easily be united with most of them by art.

STAUROLITE. Prismatic garnet.

STEAM. Water converted by heat into vapour. Steam is applied to the heating of houses, &c. and the ebullition of liquids. To these it is well adapted, as in its condensation, or return to the liquid state, it gives out its superabundant, or latent, heat, to surrounding bodies. The thermometer indicates no more heat in steam than in boiling water; still its heat is 800 degrees more; but this portion is latent in it, and is necessary to preserve it in the gaseous state: consequently, when it comes in contact with the cold air in a room, or with a cold liquid in a vessel, it is itself condensed, and they become warm by combination with the heat which it had imparted to them. This heat, whilst it preserved the steam in the gaseous form was latent, but now it becomes sensible.—Upon this principle is founded the application of steam to the heating of houses, &c. Steam is applied to this purpose in many manufactories in London, and in the provinces. The system has so far succeeded, and has been so variously improved, that there are in London several candidates who submit for public preference, different means of generating and diffusing it. In consequence, this method of creating heat is much adopted. It is found, that all the rooms of a large house may be kept at a temperate, or at an higher degree of heat, night and day, by the steam generated from a boiler of thirty or forty gallons, worked by one bushel of coals. In some manufactories, the steam is carried through iron pipes around the skirting of the rooms; it being ascertained, that one foot surface of steam-pipe will warm two hundred cubic feet of air in a room. In some houses, steam is conveyed within the apartment, into the hollow sides of a copper cylinder, which can have any ornamental figure given to it. There is, in either plan, no dirt nor effluvia; and no possible danger exists, because the boiler may

be worked in any out-building, at a low pressure, regulated by a valve. A spirit of competition has been excited among the manufacturers of this apparatus, for domestic use; we shall confine ourselves to a description of the latest and most approved construction, and application of it, not only to the warming of houses, but to many other domestic purposes. A steam apparatus has been recently erected at St. Pancras workhouse, where a boiler of sixty gallons heats a stone bath of four hundred gallons, several times in the course of a day, for bathing sick persons, boiling blankets, beds, &c. From the same boiler, is also boiled one eighty gallon copper for washing; one eighty-five gallon ditto for cooking, and one thirty-six gallon for the same purpose; all performed by one bushel of coals per day. Similar work is done at St. Andrew's workhouse, with three pecks of coals per day. At Cheltenham, the late Mr. Thompson not only heated his baths with steam, but also the air of the dressing-rooms. At Mr. Ramshaw's, Fetter-lane, a steam apparatus has been introduced for copper-plate printing, which supersedes the use of twelve noxious charcoal fires. Steam has also been applied to the warming of hot-houses. In the application of steam to the boiling of liquids, as at Whitbread's brewery, by means of a worm conveyed through the midst of the liquors, five or six hundred barrels of wort are boiled in half the usual time, and two chaldrons of coals are saved in one day. Steam has also been introduced into many other breweries. No other copper is requisite besides the steam boiler; the wort and liquors being boiled in wooden vats. It is likewise used for the purposes of distillation. The following is a summary of the advantages which will result from substituting steam in place of culinary fires, for the heating of houses, &c. 1. Steam saves half the quantity, and three-fourths of the cost of coals or other fuel. 2d. Steam can be made to create any degree of temperature required. 3d. Steam diffuses heat equally throughout an apartment, every side and every part being as warm as every other side and part; and the people in a room are not (as with fires) frozen on one side, whilst they are scorched on the other. 4th. Steam, as diffused in metallic enclosures, creates neither dirt, dust, nor noxious odour. 5th. Steam is free from the dangers which attend common fires; for no house can be set on fire by the heat of steam; and there is no hazard of the dreadful accidents which arise from the clothes of females and children taking fire. 6th. Steam warms not merely the room into which it is conveyed, but all the adjoining rooms; and if made to act in a cylinder at the bottom of a well-staircase, or in the hall of a house, it will increase the temperature of the whole house. 7th. Steam, by causing the heated air to ascend, promotes the ventilation of a room, and the renewal of the air, by means of an orifice and pipe in the upper part of that room. 8th. Steam renders chimneys and fire-places unnecessary, and will therefore diminish the expense of building houses. 9th. Steam will heat several small houses from a common boiler at a joint expense. 10th. Steam will warm the largest as well as the smallest apartments, and parts remote from the boiler, as highly as those near; that is to say, it would warm the cathedral of St. Paul's, and every remote corner of it, as completely as the smallest cabin. 11th. Steam renders kitchens and fires unnecessary under the roof of a dwelling; as it can be conveyed from any out-building to a cooking apparatus. 12th. It puts an end to the use and employment of the wretched climbing boy. In a word, the introduction of steam for generating and diffusing heat, is likely, not only to change the entire economy of our houses, but to promote comfort, health, cleanliness, and security, beyond all former anticipations of art or genius.

STEARINE. A component part of fat.

STEATITE, or SOAPSTONE. A subspecies of rhomboidal mica. Specific gravity 2·4 to 2·6. Its constituents are silica 44, manganese 44, alumina 2, iron 7·3, manganese 1·5, chromium 2. Humboldt informs us, that there are savages on the Oronooco, who receive into the stomach large portions of potter's clay, and there are many savages who eat great quantities of steatite, but what nourishment it can afford them it is not easy to ima-

gine. Klaproth has analysed the steatite of Cornwall, of which he gives the following account: The steatites of Cornwall (talcum smeetes, Linn.) occur at the Cape Lizard, in serpentine mountains, which it cuts through in small perpendicular or rake veins. The finest sort of it is white, with bluish or reddish spots, resembling marble. When fresh from the mine, it is so soft that, like soap, it may be abraded with the knife. It is used in making porcelain. The working of these mines is carried on by the house of the porcelain manufacture at Worcester, which pays £20 sterling for the ton of 20 cwt., because the bringing it out to the day is extremely uncertain and dangerous, the serpentine rock breaking in so frequently. There also occurs in these mines, another sort of it, less fine and having spots of iron-ochre, as well as a third brown red variety mingled with green. Not far from thence, at Ruan Minor, also in serpentine, there is found both a grey-white and a light slate-blue soap rock, or steatite, and also a whitish steatite crossed by calcareous spar, which gives it a smooth shining fracture.

STEEL. A carburet of iron. See *Iron*. To make cast steel;—put 20 parts of pure iron, in small pieces into a crucible, with 6 parts of powdered chalk, and 6 parts of powdered Hessian crucible ware. Dispose the whole, so that after fusion the iron may be completely covered, to prevent the least contact with the air. Now give the crucible a gradual heat, and then expose it to a white heat. Generally, an hour will be sufficient to convert two pounds of iron into exceedingly hard steel, capable of being forged; an advantage not possessed by steel in the usual manner. Here the iron is formed into a carburet by combination with the carbon of the chalk and crucible powder. In the present age of invention and improvement in the arts, none seems to promise greater benefits to society than Messrs. Perkins, Fairman, and Heath's siderographia, or mode of engraving upon steel, and then transferring the same to steel or other metals. This invention deservedly demands, while it receives the admiration of every lover of the fine arts; and at the same time it presents the means of perpetuating whatever is beautiful in the art of engraving, and will probably produce a general refinement in the public taste, by furnishing engravings of the most beautiful kinds, at the same cost as those of inferior execution. The advantages to be derived form the use of this invention are various; but that to which it has been applied almost exclusively, and with perfect success, has been, to secure paper currency from forgery; an object not before attained by any other plan, but of the first importance as it respects national morality, which cannot be maintained except by the absence of temptation to crime. Having been permitted to examine the siderographic process, we proceed to lay a concise account of it before our readers. Steel blocks, or plates of sufficient size to receive the intended engraving, are softened or decarbonated upon their surfaces, and thereby rendered a better material for receiving all kinds of work than even copper itself. After the intended work has been executed upon the block, it is then hardened with great care by a new process which prevents injury to the most delicate work. A cylinder of steel, previously softened, is then placed in the transferring press, and repeatedly passed over the engraved block, by which the engraving is transferred in relief to the periphery of the cylinder, the press having a vibrating motion equalling that of the cylinder upon its axis, by which new surfaces are presented equalling the extent of engraving. This cylinder is then hardened, and is ready for indenting either copper or steel plates, which is done by placing it in the same press before described, and repeatedly passing it over the copper or steel plates, thereby producing another engraving identically like that upon the original block; and this may be repeated upon any required number of plates, as the original engraving will remain to produce other cylinders if ever required; and when transferred to steel plates and hardened, these will also serve as additional matrices for the production of new cylinders. This invention promises to be of great advantage to some of our manufactures, particularly that of pottery, which may now be embellished with beautiful engravings, so as to place the successful competition of other nations at

a more distant period. It may also be applied with great advantage to calico printing, by producing entire new patterns upon the cylinders from which they are printed, an object of great importance to our manufacturing interests. These are among its obvious applications; but as a means of rendering forgery impracticable, it claims the attention of statesmen and the gratitude of philanthropists, who shudder at the victims which are now immolated to the laws, by the facility with which they may be violated. Very important experiments were made on a small scale at the laboratory of the Royal Institution, London, on alloying steel with other metals, and the result has been beneficial to society. Similar alloys have been made for the purpose of manufacture, which have been equal, if not superior, to those of the laboratory: the most valuable alloys are formed of silver, platina, rhodium, iridium, and osmium, and pallidium; all of which have been used in the large way, except the last. Only about 1-500th part of silver will combine with steel; and when more is used, the silver appears in the form of a metallic dew lining the top and sides of the crucible. Globules of silver are also forced out by contraction on cooling, and more by the hammer in forging. When the forged piece is examined by dissecting it with diluted sulphuric acid, threads or fibres of silver are seen mixed with the steel; but when the proportion is only $\frac{1}{500}$ part, neither dew, globules, nor fibres appear, the metal being of a perfect chemical combination, and the silver could only be detected by a delicate chemical test. In an experiment where eight pounds of steel were combined with $\frac{1}{480}$ of silver, the metal produced was found to be harder than even Indian wootz, with no disposition whatever, either to crack under the hammer or in hardening: it is likely therefore, that in cutlery, and in the manufacture of various tools, that this alloy will be much used. An alloy of steel and $\frac{1}{100}$ part of platinum was found not so hard as the preceding, but to possess considerably more toughness, and will therefore probably hereafter be much employed where tenacity is much required. The expense of platinum will not, in most cases, prevent its being used. Alloys with rhodium, with iridium and osmium, are found excellent; but the rarity of these metals, and of palladium, will not allow the hope of general utility. When pure iron is substituted for steel, the alloys are less subject to oxidation. It is suspected that there are other substances besides carbon, which give iron the properties of steel.

STEINHELITE. Blue quartz of Finland.

STIBIUM. Antimony.

STILBITE. Pyramidal Zeolite.

STILPNOSIDERATE. A mineral of which the constituents are oxide of iron 80·5, silica 2·25, water 16, with a trace of manganese.

STINK-STONE, or SWINE-STONE. A kind of limestone.

STRAHLSTEIN. Actinolite.

STRATA. These consist of extended parallel layers of similar substances lying one above the other, of different depths or thicknesses, and they appear to be results of deposits of the same substances in a state of solution, or of an action like that of water, which tends to reduce all materials which are its patients to a level. This action of water appears to be the reasonable cause of the formation of most strata; but there is a mechanical action and re-action between substances of different density and bulk, arising from their centripetal force, which constantly tends to equalize their separate levels. In the present visible creation, the upper stratum consists of the fine mould of decayed vegetable and animal matter, of thicknesses proportioned to the luxuriance of the site. Beneath the upper stratum usually lie others, evidently of marine formation, created by such an action as that of the sea. Beneath this, Cuvier has distinguished another layer of animal and vegetable remains; then a second series of marine strata; beneath these a third vegetable stratum; and again, a third of marine strata; all so many effects of obvious, yet remote causes. Another cause not generally regarded, tends also constantly to create the upper stratum: viz. the dust which falls from the atmosphere, and deposits a sensible thickness in every year. Whether this arises from storms, and the action of the atmosphere, which raises the

dust that falls, or whether there may not be a constant aggregation of gaseous atoms in the medium of space through which the earth moves, are questions which the observation of man may never be able to determine; but if the latter be the case, and the supposition accords with many phenomena, then the bulk of the earth may be considered as gradually increasing; and hence the remains of vegetation and other phenomena of the surface being constantly found below the level of the sea. The chief element concerned in all these formations and changes, is time. The compositions of nature often employ thousands of years.

STRATA OF ENGLAND.

Every sort of stratum contains concretions, in nodules or layers, peculiar to itself. For instance, chalk contains black and glossy flint. Portland stone, and all other limestone strata, contain flint varying in colour, from ash-grey to a dull black. Clay, and all the argillaceous strata contain septaria. And even sand has its iron-stone, principally in layers. Most of all of the stone strata are laminated; the upper beds of which are much thinner and more easily to be perceived than those at a greater depth in the same stratum; the lower beds generally have the appearance of more solidity, as well as greater thickness, but nevertheless they are in layers. Even lava, trap, toadstone, and similar volcanic productions, are said to have flinty nodules in abundance, and sometimes of great beauty. The British strata are arranged nearly in the following order:

1. Vegetable mould, a foot or two in thickness.

2. Brick earth, a few feet in thickness, as in the brick-fields near London, and many other places, but by no means general.

3. Beds of shells, sand, and gravel, from five to thirty feet in thickness. These are exposed to view in the cliffs on the coast of Essex and Suffolk. The shells and sand have been mostly washed off in Middlesex and Surrey; but the gravel, a few feet in thickness, remains, and it is used for making and repairing the roads. In some places it is a free sandy gravel, and in other places it is mixed with a chestnut-coloured clay. The greater part of the materials which compose this stratum have been formed in the places where we now find them; but such of them as consist of rounded pebbles have been fragments of older strata, broken and rolled to their present situation by the ocean. This stratum is known to extend over Middlesex and Essex, as well as the north side of Surrey, some parts of Kent, Hertfordshire, Buckinghamshire, and Suffolk; it is also met with at Hartley row, on the road to Basingstoke, at West-cowes, on the north side of the Isle of Wight, and many other places, but with interruptions and displacements, by being occasionally washed away

4. London clay. Immediately under the foregoing formation is a clay stratum of from one or two hundred to nearly three hundred feet in thickness. Its colour at the top, and to the depth of five or ten, and occasionally to fifteen or twenty feet, is a chestnut. At that depth, the fissures of this stratum become stained with sky blue; and at thirty or forty feet from the top, the whole substance of this clay is of a lead colour. The depth of colour increases with the depth of the stratum, to a much darker blue, or even to verge on a dull black. The chestnut-coloured part of this clay is used by the brick-makers, and that of a lead-colour by tile-makers. But the latter is equally capable of being manufactured into bricks of a red colour. Though this or any other clay, on being mixed with chalk, and the mixture washed, will produce bricks, tiles, and other earthen ware, of pale sulphur or cream colour. This blue clay contains septaria, (balls of indurated clay, iron, and spar) in nodules and layers, as well as occasionally many crystals, resembling icicles, three or four inches in length. These septaria balls, on being reduced by the hammer, then burned in a lime kiln, and ground, produce Parker's Roman cement, in a state of powder, which requires only the addition of about fifty per cent. of silicious sand, previously washed till it is free from animal, vegetable, and earthy matter, and then to be properly watered, worked, and used in a state of mortar, to make an excellent cement for walls of every kind; or any sound wall, by being plastered over with it,

receives a coat which becomes an actual stone of the harder kind, much more so than Portland stone. This stratum of clay also contains, not far below the surface of it, the tusks of elephants, the bones of animals, and petrified wood; and it prevails near the surface of the ground through Middlesex and Essex, the northern parts of Surrey, on the hills above Hurley, in Berkshire, at Hartley-row, and the north side of the Isle of Wight, in Hampshire, as well as in Buckinghamshire and Kent, through Suffolk, Norfolk, and farther northward along the east coast. Very little water is met with in this clay, and that is in every case of a bad quality. When good spring water is not to be met with above this soil, it is not to be obtained without digging through it, as well as through a stratum of marine shells which lie under it, into the sandy subsoil. Every interstice of that sand is full of excellent water, and it usually rises in the well to a considerable height, even in many cases to overflow the surface. But all communication between the water in the well and the lead coloured clay (at the back of the steening) must be prevented, or the water in the well will soon become impregnated with the bad qualities of the clay. Though that aptitude in this clay to spoil water, for social purposes, is in a great measure prevented, in such wells as have the water rise so much as to overflow in a full stream; and that would generally be the case in low situations, if the well-diggers were to complete their steening to the stratum of shells, and then depend on boring one large augur hole through the marine stratum, into the sand which lies under it. This formation of clay has been dug through in sinking wells at Clapham, Stockwell, Brixton, Norwood, and other places on the north-east side of Surrey, as well as at many places in Middlesex. The road dug through Highgate-hill was wholly in this clay, and the works at that place brought to light many petrifactions. Among the rest was a tree thirty or forty feet below the surface, which evidently shewed that worms had eaten their way through it in every direction, and that the cavities occasioned by them were nearly filled with mineral matter. An elephant's tusk was found in this clay, not far below the surface of it, by the workmen employed in a brick-field at Kingsland, about a mile on the north side of Shoreditch Church, London. This tusk was rather thicker and more bent, but not longer than those of the living animals at this time.

5. A stratum of shells, pebbles, and sand. A bed of shells, consisting of oysters and cockles, though mostly the former, sometimes whole, but more frequently in fragments. These shells are cemented together by the lead-coloured London clay, and the glutinous remains of fish. They compose a layer of two or three feet in thickness. Under that there is generally eight or ten feet of a chestnut-coloured loam, containing a few sea shells, reposing upon another bed of compact shells a foot or two. The whole of this formation is about twelve or fifteen feet in thickness. This bed of shells has been seen in many places, but it is not supposed to exist universally; for instance, it does not appear in the pits for fire-clay at Ewell, nor in those for tobacco-pipe clay in Purbeck. But it is said to be invariably found under the London clay, in sinking wells of considerable depth in Middlesex and Surrey. In the place of these shells at Ewell, where they were expected to basset, or rise gradually to the surface, the fire-clay is found in two or three layers of different quantities, rising from under the edge of the London clay. The uppermost of these beds is of a reddish or ruddy colour, with blue veins. The next is a bed of clay, about three feet thick, not much unlike fullers-earth, and this rests upon sand of a similar brown colour. That is, the lowest bed of this fire-clay lies upon the upper bed of Blackheath sand, beneath which may be seen the lower bed of white sand, and under that the chalk. These beds of clay and sand, mixed in various ways and proportions, are manufactured into tiles and bricks, for ovens, furnaces, and other fire-places, where a great degree of heat is to be withstood. The Norden clay is in a similar situation to the fire-clay at Ewell. The pits are dug in a tract of barren land, and situated about one mile

north-west from Corfe Castle. A section of one of the pits exhibits the following appearance:—

1st, Vegetable mould, a peat earth, producing heath	1 ft. thick.
2d, White clay and sand, in patches	5 ft. thick.
3d, Sand, stained with iron, of a chestnut colour	10 ft. thick.
4th, Iron sand-stone	1 ft. thick.
5th, Ash-coloured clay, with patches of coal. This colour may be attributed to the stain of the coal	10 ft. thick.
6th, Coal, stained, in patches, with white clay. This coal is said to be unfit for domestic use, owing to its sulphureous smell	3 ft. thick.
7th, Pipe-clay, white and compact, in two beds, divided by a layer of chocolate-coloured clay one foot thick. The lower bed is esteemed the best	17 ft. thick.

The very best white clay is the only sort sent to market from this place; a greater quantity of it, with small stains of coal, as well as the coal itself, are shovelled into the pits and wasted.

8th, Sandy clay of the same white colour as the best. It is nearly dry to three feet deep, and below that the springs prevent any deeper search	3 ft. thick.

This clay is on the north side of a lofty chalk down, towards which it ascends and feathers out so as to be lost, at one hundred yards or more from the skirt of the down. The coal which covers the clay obviously originated from timber and other wood; the specimens submitted to examination were found to contain a portion of mundic and sulphur.—Blackheath sand lies under the foregoing bed of marine shells. The upper part of this formation consists of pebbles, of the size of horse-beans, marbles, and walnuts; they are of many colours, and vary in depth from a foot or two to ten, fifteen, or twenty feet. They form the surface at Blackheath, Woolwich, and other places in Kent, as well as on Shirley-common, Addington-hills, and Croomhurst, in Surrey; and they are to be seen in many other places. The pebbles are nearly free from earthy mixture, and, where they form the surface of the soil, it is extremely unproductive. Loose sand lies immediately under them; it is of a fawn colour, and ten or fifteen feet in thickness; beneath that is thirty or forty feet of sand, nearly white, which is dug in the pits, at Shirley, in Surrey, but only to the depth of fifteen feet, for the use of masons, glass-cutters, and household purposes; it continues to a greater depth, but the rest of it is drowned in water. At these pits the vegetable mould and pebbles to be removed from off the sand, is barely three feet thick.—Under London, and in the neighbourhood of that city, as well as wherever this formation happens to be in a low situation, it is full of water; but where it rises to the surface, it is dry sand. A fine section of it upon chalk may be seen in a large pit at Upper Greenwich, very near Blackheath, in Kent. It may also be seen to rest upon chalk, on the south side of Addington-hills, Croomhurst, and other places in Surrey. The sandy part of this formation lies between the fire-clay and the chalk in the brick and tile fields, on the side of the roads at the east end of Ewell; it is believed to lie under the pipe-clay of Purbeck, but in these places the pebbles are found to be missing. It also rises from under the lead-coloured clay of London, and forms the surface across the middle of the Isle of Wight, in a direction from east to west. It is found in the same position in Studland Bay, Purbeck, but it is not universally found upon chalk, as the places are very numerous in which different shades of chestnut-coloured clay is the immediate covering of chalk. But wherever this formation exists, it lies upon chalk, and it rises to the surface, or bassets out on the London side of all the chalk hills.

The excavation at Highgate, for the archway or tunnel, passed at so great a depth in the London clay as to cut through it, and break up the marine bed which lies under the clay. In this marine bed were found many fossil oysters, lobsters, sharks' teeth,

mackerel, muscles of one inch in length, and masses of other perfect shells, one-fourth of an inch in diameter. The two last sort of shells were in some instances cemented to the clay-balls, called *septaria*.—The bottom of the excavation which failed under Hornsey-lane, is not many feet above the stratum of chalk.

6. *Chalk*.—This formation is the next older stratum, and that it is a marine sediment is proved by its containing the shells of oysters, muscles, cockles, sharks' teeth, and upwards of fifty other fossils. The state in which these fossils are found, prove (says Mr. Parkinson) "the matrix in which they are imbedded was formed by a gradual deposition from the surrounding fluid, which entombed these animals while living in their native beds." The stratum is now of various thicknesses, up to eight or nine hundred feet; soon after its formation, or before it was fully compressed, it must have exceeded a thousand feet in thickness. It is porous, loose, and dry near the top, but at greater depths it is compact. At two-thirds or three-fourths of its depth is obtained hard chalk, tinted brown, which is broken and burnt into the substance called Dorking lime, which has long been used in London, in the composition of mortar for superior cement. The lower beds of chalk, like most other strata, increase in hardness in proportion to their greater depth, until it becomes stone. Within a few yards of the bottom of this formation, there are one or more beds of it, so hard as to be nearly equal to the best Portland stone. But, as an exception to the usual order of things, this hard stone, in Merstham quarry, lies on a bed of soft easy-working stone, called fire-stone, which is three or four yards in thickness. This stone is calcareous, and of a deep cream colour. It is dug and squared at Gatton, Merstham and Godstone, at per cubical foot, for the London masons, who use it in fire-places. The softness of this stone, and the ease with which it can be worked, are the insufficient reasons which induced masons to use it, in preference to the much harder and better parts of the quarry. The upper parts of the chalk stratum, to about six hundred feet in thickness, contain layers and nodules of black glossy flint; and the lower beds of it, which are two or three hundred feet in thickness, contain flint of an ash-grey colour.

Strata are every where bounded by a ridge of chalk (except where the sea-coast interferes), which slanting off, forms a large concave area in which they seem to have been deposited, and hence the term chalk basin, of which the most northerly includes the metropolis, and has been called the London basin, while the southern is less properly termed the Isle of Wight basin, since it includes only the northern half of that island, which is traversed east and west by the edge of the basin. The boundary of the first of these basins may be stated generally as a line running from the inner edge of the chalk, south of Flamborough Head, in Yorkshire, nearly south, till it crosses the Wash, then south-west to the upper part of the valley of the river Kennet, near Hungerford, in Wiltshire, and thence tending south-east to the north of the Thames, and the north-west angle of the Isle of Thanet; in all these directions the bounding line is formed by the chalk hills; on the east side the boundary is the coast of the German Ocean. The boundaries of the Isle of Wight basin may be generally assigned by the following four points;—On the north, a few miles south of Winchester; on the south, a little north of Carisbrook, in the Isle of Wight; on the east, Brighton; and on the west, Dorchester. It is every where circumscribed by chalk-hills, excepting where broken into by the Channel between the Isle of Wight and the main land. Among the substances found in these basins, none are more remarkable than the strata of bluish or black clay, which, from its forming the general substratum of London and its vicinity, is usually called London clay; it occasionally includes calcareous and silicious sand or sandstone; and in other countries the corresponding stratum is nearly entirely a calcareous freestone; such is the calcaire grossier, of which Paris is chiefly built. This clay is with us remarkable for its horizontal layers of septaria, which are flattened masses of argillaceous limestone, traversed by veins of carbonate of lime, or sulphate of baryta. The London

clay also affords specimens of blue pulverulent phosphate of iron, pyrites, amber, fossil, resin, and selenite; the hardness of the water found in this stratum is chiefly referrible to its containing the last-mentioned substance in solution. The blue clay is also abundant in organic remains of crocodiles, turtles, vertebral and crustaceous fish, and testaceous mollusca in great number and beauty, but differing, though often very slightly, from recent genera; yet extinct genera, so common in the older formations, are rare in this; it is said, however, that cornua ammonis and belemnites have been found. Zoophytes are likewise of very rare occurrence. Among vegetable remains there are found pieces of wood in various states, and others perforated by teredines, like those which infest the West Indian seas. In the Isle of Shepey there have been found in these clay strata no less than 700 varieties of fruit and ligneous seed-vessels, very few of which agree with any known varieties at present in existence: some seem to be species of cocoanuts, and various spices. The greater part of the soil of Middlesex, Essex, and Suffolk, and considerable portions of Berkshire, Surrey, and Kent, consist of London clay; and in the Isle of Wight basin, it forms the whole coast from Worthing, in Sussex, to Christchurch, in Hampshire, and extends from the latter place, inland by Ringwood, Rumsey, Fareham, and passing a mile or two south of Chichester to Worthing. The country is generally low, or only slightly undulated, and as a soil it is productive of fine oak, elm, and ash timber, but requires chalk to render it productive in corn; when well manured it forms excellent garden ground, as the vicinity of London amply testifies. The history of the wells in London is very interesting, as connected with the clay formation, and they may be divided into three classes. 1. Those which are in the gravel above the clay. 2. Those in the clay itself. 3. Those which derive their supply from the strata below the clay. A great deal of good limpid water is derived from the first class, where its escape is prevented by the dense nature of the substratum. Sometimes it is rather hard, and sometimes brackish, but generally speaking very good drinking water. This supply, however, though abundant, is generally insufficient for the consumption of our great manufactories; yet some of the large sugar-houses, distilleries, and breweries, exclusively employ the water of these shallow wells, which in some parts of the town are remarkably productive. Where the diluvial gravel is very thin, or altogether wanted, there are wells sunk in the blue clay, but the water is extremely impure. Selenite is its common ingredient, and sometimes the pump delivers nearly a saturated solution of that salt. Sulphate of magnesia, sulphate of soda, sulphate of iron, and occasionally sulphuretted hydrogen, are also found in the waters from the blue clay. The supply of these wells is very precarious, and, literally speaking, very scanty; for they generally receive the drippings of the thin superincumbent diluvium. The third class of London wells includes those which perforate the clay, and derive their water from the strata beneath it; these have lately become very numerous, and are truly important in many of our large manufactories, which were before obliged to employ the muddy water of the Thames. The water which supplies these wells rises from the sands below the London clay; and if care be taken to exclude the impure springs which filter in from above, it is generally remarkably soft, excellently adapted for every domestic use, and, what is of principal importance, it never fails, and is not affected by rains or drought: traces of common salt and of carbonate of lime are usually discoverable in it, but what is most remarkable is, that when evaporated it leaves a highly alkaline residue, chiefly of carbonate of soda, which sometimes amounts to four grains from the quart. The depth of these wells is, of course, dependent upon the thickness of the clay stratum. At Whitechapel, east of London, some wells have been carried through it, and do not exceed 100 feet; at Tottenham it is about 120 feet; in the Strand, 200 feet; in St. James's-street, 235 feet; at Chelmsford, 300 feet; and at Wimbledon the well is 530 feet deep, and it is doubtful whether the clay is actually there pierced. By indirect examination,

the greatest thickness of the clay in the London basin has been estimated at 1000 feet. The height to which the water rises in these wells will depend much upon their locality. Upon perforating into the strata whence it issues, it generally rushes forth with violence, and assumes an invariable level; and there are several instances of its overflowing in a perpetual stream; of which the well at Merton, that sunk at Norland hill, behind Holland-house, and that lately made at Ravenscourt, at Hammersmith, may be quoted as instances. Above the blue clay we find, in certain situations, distinct superimposed strata; thus, on the east coast of Suffolk, low cliffs resting upon the London clay are found to consist of sand and gravel, enclosing peculiar fossils; the whole mass is known by the appellation crag. Of the shells which it contains, the greater number resemble the recent shells of neighbouring seas; there are, however, a few extinct varieties, and among them the *murex contrarius*; though, what is very curious, the fossil shell with the whirls in the ordinary direction is also found here. There are likewise a few fossil bones, much impregnated with iron, and belonging to unknown animals. This formation is seen at Walton Naze, in Essex, and caps the cliffs on both sides of Harwich, extending considerably into Suffolk and Norfolk, where it forms a fertile soil. The sandy deposits which cover certain parts of the London clay, and which are denominated Bagshot sand, must also be considered among the deposits which geologists have lately termed the upper marine formation. Bagshot Heath, and the sand of Hampstead and Highgate are of this description. It is, however, in the Isle of Wight that we meet with the most interesting series of the strata above the blue clay. The cliff called Headen Hill, on the north-west coast of the island, exhibits an admirable section of these formations. This hill consists of several strata; the uppermost overlies the upper marine formation, and contains abundance of fresh water shells without any admixture of marine exuviæ, together with seeds of a flat oval form, and parts of coleopterous insects; it has been termed the upper fresh water formation, and may be seen in many other parts of the island, especially about Cowes, Bembridge and Binstead, and it is quarried as a building stone between Calbourne and Thorley. To this stratum succeeds the upper marine formation, and then we arrive at a series of beds of siliceous, calcareous, and argillaceous marles, abundant in fresh water shells, but wholly deficient in marine relics; these beds constitute the lower fresh water formation, and may be seen extending round the north side of Headen Hill into Totland Bay. We now descend to the strata which lie immediately below the London clay. They consist of irregular alternations of sand, clay, and pebble beds, forming a series of contemporaneous depositions intermediate between the chalk and clay, and usually described under the very inappropriate term, plastic clay formation. The sands are of various colours and qualities, so are the clays, some of which are used for pottery, some for tobacco-pipes, and some for bricks: they contain imperfect coal, pyrites, gypsum, and abundant organic remains in some places, while in others there are none. The highest northern point at which this formation is seen is near Hadleigh, in Essex, whence it borders the clay to about five miles south-west of Braintree. Halstead and Coggeshall, and the intermediate tract, are upon the plastic clay; it also extends from Ware to near Edmonton, over Enfield chase, and passing close to St. Albans, skirts the London clay to Uxbridge, on the north of which it takes a westerly direction towards Beaconsfield, and thence runs nearly south to the Thames. It is seen again at Reading, in Berkshire, and extends thence, though not in a straight line, to a few miles beyond Hungerford, which may be said to be its extreme point on the west, except a few outlying masses south of a line from the latter place to Marlborough in Wiltshire. Turning south from a little on the west of Hungerford, to the foot of the chalk hills, it passes east by Kingsclere, Basingstoke, and Odiham in Hants, and Guildford in Surrey; thence rather in a north-easterly direction a little to the south of Croydon, it continues to skirt the foot of the chalk hills by Farnborough and Chatham in Kent,

and thence by Milton and Ospringe, to the foot of Boughton Hill, where it divides; passing, on the one hand, in a north-easterly direction, it skirts the London clay to Whitstable on the coast; and on the other nearly east to Canterbury, (which stands on the beds of this formation,) to the coast of the Reculver, whence it again passes to the south-west, except where marshy lands intervene, by Sandwich, which is built upon it, a little to the south of Deal. The supermedial order of rocks, though admitting of several subdivisions, may generally be referred to the following classes, enumerated in the order of their succession descending from the plastic clay. 1. Chalk. 2. Ferruginous sand. 3. Oolite, including lias. 4. New red sandstone and magnesian limestone. The chalk formation from its extent and contents forms one of the most remarkable and interesting features of English geology. Where in contact with the superincumbent clay, it generally exhibits symptoms of having been exposed and worn previous to its having received that covering, as if an interval had existed between its completion and the deposition of the formations that repose upon it. The upper strata of chalk are remarkable for their layers of nodular flints, which are generally arranged nearly in a horizontal position. Sometimes tabular masses, and even veins of flint, are observed, the latter traversing the strata at various angles. Nodules of pyrites, and of crystallized carbonate of lime are also found in these beds, and a very interesting series of organic remains of genera and species nearly all extinct. The lower strata of chalk are marked by the deficiency of flint and organic remains, and are commonly more or less argillaceous, exhaling an earthy smell when breathed upon, and degenerating into what is usually called chalk marle, a compound of chalk, clay and sand. Where chalk is of uniform texture, it is generally deficient in springs; but where it happens to be traversed by beds or veins of substances of softer or sabulous texture, there the water often percolates and yields an abundant supply. The agricultural qualities, and the aspect of chalk are too well known to acquire particular notice. A loose silicious sand, occasionally aggregated by a calcareous cement, and containing particles of mica and green earth, forms the stratum upon which the chalk rests, and which is of considerable thickness in the southern counties, but more obscure in the midland and northern counties The fuller's earth, and sulphate of barytes of Nutfield in Surrey, together with crystals of quartz and carbonate of lime, and nodules of chalcedony and chert, are found in this deposit; it is also very abundant in organic remains. It is, however, difficult to draw any correct line of demarcation between this green sand with its accompanying clays, and the great iron-sand formation, which we see in such perfection in the cliffs at Hastings. This iron-sand, however, is comparatively scanty in organic remains, so that the green sand and iron sand bear in this respect some analogy to the upper and lower chalk.

The Foreland, between the bays of Studland and Swanage, in Dorsetshire, shew a pretty good section of the chalk stratum; in that place it was estimated, with an attention that was little less accurate than measuring, the chalk with black flints to be six hundred feet, and the lower beds to be two hundred feet in thickness. High-down, at the south-west corner of the Isle of Wight, is all of the chalk formation, and it rises 700 feet above the sea. This chalk mountain has been rent from the horizontal chalk stratum; on that occasion, one edge of it has been turned up, and the other down, until the strata settled in a vertical position. This movement included two beds of clay, and many of sand beneath the chalk; these are vertical, and exhibit all the colours of the rainbow adjoining the down in Alum bay.—The lower beds of the chalk formation, and every fissure in them, are, with few exceptions, completely filled with water. All the rain and snow which fall upon chalk, percolate downwards to its base, where the water is stopped by a subsoil of blue clay; and that occasions it to accumulate in the chalk, until it rises to such a height as enables it to flow over the surface of the adjoining land. In this manner are formed the springs and rivulets which issue near the foot of every chalk-hill. In the Cove, at West Lulworth, fine

fresh-water streams issue from the base of the adjoining mountain of chalk, just above the level of the sea. The water which issues from the chalk at Croydon, Beddington, and Carshalton, form the river Wandle; and the same thing happens at Ewell, Merstham, and other places.—Mr. Hilton Joliffe made a culvert several hundred yards in length, from a level so low as to pass through his works in the chalk at Merstham, by which a rivulet of water, sufficient to turn a mill, is constantly running off. This culvert drains the water off in such a manner as to enable him to raise the lower beds of the chalk stratum: these consist of chalk stained with iron, to burn for Dorking lime; of a stone which is supposed to be nearly equal to Portland stone; and fire-stone lying immediately under each other, without any intermediate matter, and in the order in which they are mentioned. The chalk stratum passes under London, at the depth of three, four, or at the most within five hundred feet. It is said, that the chalk stratum was found at the depth of one hundred and eight feet, in sinking a well at the victualling-office, Deptford. It gradually rises to the surface in about ten miles, as at Croydon and other places; it then lies immediately under a thin vegetable mould, and continues to ascend for eight or ten miles more to the south; there it has attained its greatest height, and forms a range of stupendous hills on the north side of the towns of Folkstone, Ashford, Maidstone, Wrotham, and Westerham, in Kent; Godstone, Reigate, Dorking, Guildford, and Farnham, in Surrey; as well as on the north side of the South Downs, in Sussex; and above all the precipices of chalk stratum in England.

7. Chalk of a deep blue colour, and calcareous as chalk.—A section of this clay, well defined, measured fifteen feet; towards the bottom of the bed it is rather laminated. There is a lower bed of it, but so much mixed with sand as to render it rather of a lighter colour than the above; and this is fifteen feet thick. These formations of clay were seen immediately under the chalk, near the Chine, at St. Catherine's, and at Compton-down, on the south side of the Isle of Wight, and on the north side of Swanage-bay, as well as at Lulworth Cove, in Dorsetshire. This stratum lies immediately under the chalk, and rises to the surface on the south side of the downs in Surrey and Kent; as well as on the north side of the South-downs in Sussex; it every where forms a soil of so dark a blue colour, as induces the country people to call it black land. The specimens of this formation, which have been examined, shew that it is a clayey marle, which effervesces very freely with acids.

This formation of clay lies between chalk and sand of great depth; therefore, it is obvious that the places are very numerous in which much of the vast quantity of water, now lodged in the lower beds of chalk, might be passed through this tenacious stratum into the sand under it, by the easy means of boring a sufficient number of large augur holes, a few yards deep

The third of the four subdivisions of the supermedial rocks, namely, the oolitic series, is chiefly important as the great repository of the principal architectural materials which the island affords, and may be generally described as consisting of a series of alternating oolitic limestones, of calcareo-siliceous sandstones, and of argillaceous and argillo-calcareous beds, repeated in the same order. Three of these systems appear to comprehend all the beds which intervene between the iron sand and the new red sandstone, and each system lies upon a thick argillo-calcareous formation, constituting a well marked line of demarcation, the oolitic rocks of each system forming a distinct range of hills separated from those of the other systems by a broad argillaceous valley. In England, these formations occupy a zone having nearly thirty miles in average breadth, extending across the island from Yorkshire on the north-east, to Dorsetshire on the south-west: they are characterised by peculiar organic remains, among which we enumerate many extinct genera of oviparous quadrupeds, apparently inhabitants of salt water only, various vertebral fishes, testacea of all descriptions, coralloid zoophytes, encrinites, &c. The whole of the oolitic series reposes upon argillaceous deposits, the uppermost of which are deep blue marle, with a few irre-

gular beds of lime-stone, which increase in frequency as we descend, and present a series of thin stony beds separated by narrow argillaceous layers. These beds are known by the name of lias; they are argillo-calcareous, and the white varieties admit of polish, and may be used for lithographic engraving, while the blue or grey lias contains oxide of iron, and forms, when calcined, a strong lime, distinguished by its property of setting under water. The lias is nearly destitute of mineral products, if we except iron pyrites, which by its decomposition, frequently produces an aluminous efflorescence, as in the alum shale of Whitby, and sometimes a spontaneous inflammation, as in the cliffs near Charmouth. Organic remains are here very abundant and interesting; they embrace more vertebral animals than one found in any other formation; among them are two remarkably extinct genera of oviparous quadrupeds, the ichthyosaurus, and the plesiosaurus. The strata which intervene between the lias and the deposits of coal, are referable to two formations very intimately connected together, viz., 1. a series of marly and sandy beds, intermixed with conglomerates derived from older rocks, containing gypsum and rock salt: and secondly, a calcareous formation, often brecciated, and containing magnesia, lying below or in the lower portion of the above series. The former deposits are commonly called red marle, or new red sandstone; the latter, magnesian limestone. Red marle is a very extensive deposit, stretching from the northern bank of the Tees in Durham, to the southern coast of Devonshire; its texture is various, and it is especially remarkable for containing beds of gypsum and of rock salt, and for the absence of organic remains. In respect to the magnesian limestone, much confusion has arisen from neglecting to distinguish between that associated with the red marl, and the older rock of similar composition associated with the mountain limestone, and from which it is distinguished by its organic remains and geographical position; the latter is also marked by the frequent occurrence of extensive beds of calcareous conglomerate. It differs from common limestone in having a sandy structure, glimmering lustre, and yellow buff or fawn colour; it often occurs in concretional masses, dispersed through an arenaceous form of similar materials; it is sometimes composed of small rhombic crystals; occasionally oolitic, and often cellular; that of Sunderland is flexible; at Ferrybridge it is fœtid; and the lime which it affords, when calcined, is injurious as a manure, unless it be very sparingly employed. Organic remains are rare in this formation. The series of rock formations included in the medial or carboniferous order, admit of the following subdivision: 1. Coal. 2. Millstone grit and shale. 3. Carboniferous, or mountain limestone. 4. Old red sandstone; and in forming an accurate notion of the geology of our coal districts, we shall be much assisted by keeping in view the mutual relations and connexions of these four substances; remembering, always, that although carbonaceous beds occur in other formations, it is only in the limits of the strata at which we have now arrived, that supplies of coal capable of being profitably worked are to be found. The coal strata, or coal measures, as they are often called, consist of a series of alternating beds of coal, slate-clay, and sandstone, the alternations being frequently and indefinitely repeated. The slate-clay or shale, differs from clay slate by its want of solidity and induration; the sandstones are usually gritty, micaceous and tender; they are used for building, paving, and the manufacture of grindstones. These strata also afford nodules of clay ironstone, the ore, whence the principal supplies of that important metal are derived in this kingdom. The organic remains of the coal strata are abundant and curious, especially those of the vegetable kingdom; they consist in the trunk, leaves, and seed vessels of various plants, all distinct from species now existing, but agreeing with the products of hot climates, and of moist situations; arundinaceous plants and ferns are very plentiful. The few shells that have been discovered are apparently marine, not fluvial. The inclination of these strata is one of the most remarkable points in their geological history; they are generally inclined, and often at a very high angle, being quite un-

conformable to the more horizontal overlying beds; they also exhibit other irregularities, among which the great fissures which traverse them, often extending for several miles, deserve peculiar notice. The coal measures rest upon beds of shale and of millstone grit, which is a coarse grained sandstone, more indurated than that which subdivides the strata of coal; it contains occasional beds of bituminous limestone thin seams of an indifferent coal, nodules of ironstone, and abundance of pyrites, and is occasionally visited by the metalliferous veins of the strata underneath. Various bituminous substances also are found in it, and abundance of vegetable impressions, together with some marine shells. Considered in a general point of view, this series is intermediate in character and composition, as it is in position, between the main coal measures which it supports, and the mountain lime which it covers, forming the natural link between them. This whole series reposes upon an important assemblage of strata, chiefly calcareous: from its association with coal, is called carboniferous limestone; as it forms considerable hills, and is rich in metals, the terms mountain and metalliferous limestone have also been applied to it. Its prevailing colour is grey, and it is generally hard enough to take a good polish; it is often magnesian, ferruginous, and bituminous; its various strata being divided either by partings of clay, grit, or shale, or by alterations of that variety of trap rock, called in Derbyshire toadstone. It contains nodules of chert, arranged something like the flint in chalk, and it is remarkable for the prevalence of empty fissures and caverns; rivers which flow across it are often ingulphed, and pursue for a considerable distance a subterraneous course; it abounds in rocky dales and mural precipices, and forms much of the most picturesque and romantic scenery of England. It is, moreover, the principal depository of the British lead mines, those of Northumberland, Durham, Yorkshire, Derbyshire and Cumberland, being all situated in it; it also affords ores of some other metals, and a variety of beautiful crystallized minerals. The organic remains of this limestone differ from those of the superincumbent strata, but resemble those of the inferior limestone. Vertebral remains, though rare, are found here; there are also many species of testacea; zoophytes, and especially encrinites and corallites, are profusely abundant, and indeed the whole mass of rock sometimes seems as if entirely made up of them, whence it has been called encrinal limestone. The strata of carboniferous limestone exhibit all the irregularities of the accompanying coal measures; they are often greatly inclined, contorted, and dislocated; and, when they alternate with argillaceous strata, they generally abound in springs, which break out often with singular impetuosity. The hot springs of Buxton, Matlock, and Clifton, are upon this formation; the waters are generally remarkably pure and pellucid, though sometimes so loaded with carbonate of lime, held in solution by excess of carbonic acid, as to deposit it as a tufa upon the adjacent rock, or incrust substances accidentally immersed; such are the petrifying springs of Matlock, Middleton, &c. We now reach the lowest member of the carboniferous or medial series of rocks, which, from its priority of deposition, is termed old red sandstone; it is sometimes separated from the limestone by a layer of shale; it is a mechanical aggregate, constituted apparently of abraded quartz, mica, and felspar, containing fragments of quartz and slate; sometimes its texture is slaty and fine grained; at others it passes into a conglomerate. Its colour is dark iron-red, brown, or grey, and it usually passes in its lower strata, by an insensible gradation, into the greywacke, upon which it is generally observed to repose. It contains few organic remains, and no important minerals. The formations hitherto described, and properly enough termed strata, follow each other as successive deposits, in regular and unvarying order; but not so with the trap rocks, they make their occasional appearance amidst all the strata, from the chalk downwards; not as regular formations, but as invading masses, dislocating and disjointing their neighbours, converting chalk into marble, sandstone into chert and jasper, coal into coke, and shale into silicious schist; they occasion dykes, or faults and ele-

vations of the strata, and violent and sudden assumption of their present situation; among the older rocks they also play a very important part, and their general history tends to clear up many difficulties connected with the granitic formations.

As an example of the mode in which the strata of the south of England are arranged, we shall give a minute description of one particular place, which is peculiarly favourable for geological observations. The strata of Alum bay, in the Isle of Wight, now seen in a vertical position, must have been originally horizontal, or nearly so. Besides other circumstances from which this appears, there are, in one of the vertical beds consisting of loose sand, several layers of flints, extending from the bottom to the top of the cliff; these have been rounded by attrition. Now it is inconceivable, that these flint pebbles should have been originally deposited in their present position: and they point out the original horizontality of the series. It appears, that between the vertical chalk hills of the Isle of Wight, and the South Downs, there is a basin, or hollow, occasioned by the disturbance of the whole mass or strata from below the chalk, to the London clay, inclusive. Hence, all the beds situated within this basin, lie above the London clay. The lower stratum is more or less argillaceous, and constitutes what is called the chalk marle. Together with the other strata, it frequently forms cliffs of considerable heights. It pulverises in frost. The chalk-marle is never quite so white as chalk, having generally a tinge of yellow. The middle and upper strata consist of chalk of extreme whiteness and purity, and are distinguished from each other chiefly by the upper containing flint nodules. Chalk without flint is usually harder than chalk with flint. The clay and sand cliffs of Alum bay exhibit the most interesting natural sections which can be imagined. The whole have evidently been formed at the bottom of the ocean, as they all exhibit marks of marine origin. The chalk which forms the side of Alum bay, is somewhat harder than usual; and the flints are shivered so as to come to pieces when taken out. Next to the chalk in the north, is a bed of chalk-marle. To this succeeds a bed of clay, of a dark red colour, streaked with white or yellow. This is divided by a bed of white sand, from a very thick bed of dark blue clay, which contains much green earth. Next follows a succession of beds of sand.

Greenish yellow sand.
Yellow sand with ferruginous masses.
Greenish sand.
Yellow, white, and greenish sand.
Whitish sand, with thin stripes of clay.
White and yellow sand.
Light green sand.
Ferruginous sand-stone.
Yellow sand, with a few red stripes.

Next to this, and in the middle of the bay, is a numerous succession of beds of pipe-clay, alternating with beautifully coloured sands.

Blackish clay, with stripes of white sand.
Sand intensely yellow.
Very white sand.
Sand of a crimson colour.
Pipe-clay, with sand stripes.
Yellow sand, with some crimson.
Pipe-clay, white and black stripes of sand.

In the middle there are three beds of a sort of wood-coal, the vegetable origin of which is distinctly pointed out by the fruits and branches still to be observed in it. It burns with difficulty, with very little flame.

v. Yellow and white sand, with crimson grey stripes.—See *Plate*.

w. Five beds of coal, similar to that already mentioned, each a foot thick.

x. Whitish sand, and brownish pipe-clay.

y. Whitish sand, with stripes of deep yellow.

z. Layers of large water-worn black flint pebbles, imbedded in deep yellow sand.

B. A stratum of blackish clay, with much green earth and septaria. In this earth are numerous fossil shells, in a very fragile state. A stream of water from the adjoining hill has worn a deep channel through the stratum, and affords a path to the bay. The strata C consist of yellowish sand, which dip about 45° to the north; and the sand D, lying on them, is nearly horizontal. To the north of Alum bay is the hill called Headen, 400 feet high, composed of the same horizontal strata.

of which the north part of the island consists. In this hill is distinctly seen the alternation of marine and fresh water deposits.

The lower fresh-water formation, appears in a series of sandy calcareous and argillaceous marles, sometimes with more or less of a brownish coally matter. Some of them appear to consist of fragments of fresh-water shells, many of which are sufficiently entire to ascertain their species. These are the lymneus, planorbis, and cyclostoma, and perhaps the helix; with a bivalve resembling the fresh-water mytilus. These beds lie immediately upon the black clay, which covers the white sand already noticed. The quantity of shells is by much too considerable to suppose that they could have been carried by rivers or streams into an arm of the sea; and in this case there would probably have been an intermixture of marine shells. We are compelled, therefore, to suppose that the spots where they now are was once occupied by fresh water, in which these animals existed in a living state. Fresh-water strata occur in other parts of the Isle of Wight. Over the lower fresh-water formation in the Isle of Wight, a stratum occurs consisting of clay and marle, which contains a vast number of fossil shells wholly marine. At Headen, it appears half-way up the cliff, and about thirty-six feet thick. The shells are so numerous that they may be gathered by handfulls, and are in general extremely perfect. From their delicacy and perfect preservation, it is probable they lived near the spots where they are now found. Immediately above the last stratum, is a thin bed of sand of six inches, upon which rests an extensive calcareous stratum of fifty-five feet in thickness, every part of which contains fresh-water shells in abundance, without an admixture of marine exuviæ. Many of the shells are quite entire. This place must have been the bosom of an extensive lake in some period far antecedent to human history; and the earth must since have undergone various revolutions, as these, instead of being now in a hollow, are at the top of a hill. Over this bed is a stratum of clay of eleven feet in thickness, containing fragments of a shell of the bivalve kind. Above this stratum is the alluvium, which here, besides vegetable earth, clays, marles, and sand, has a vast quantity of rounded silicious pebbles of various kinds. We shall conclude this article with a short account of the strata of the country around Paris, with reflections arising from the consideration of this sublime subject.

The country in which the capital of France is situated, is, perhaps, the most remarkable that has yet been observed, both from the succession of different soils of which it is formed, and from the extraordinary organic remains which it contains. Millions of marine shells, which alternate regularly with fresh-water shells, compose the principal mass. Bones of land animals, of which the genera are entirely unknown, are found in certain parts; other bones, remarkable for their vast size, and of which some of similar genera exist only in distant countries, are found scattered in the upper beds. A marked character of a great irruption from the south-east is impressed on the summits, (caps) and in the direction of the principal hills. In one word, no canton can afford more instruction respecting the last revolutions which have terminated the formation of the present continents. It appears that the country round Paris, is, in many respects, similar to the country round London; they both rest upon chalk as the foundation rock, and over this chalk are beds of clay and marle, containing the remains of fresh-water shells and of large quadrupeds: the principal difference consists in the gypsum and mill-stone, which are local formations, and are not found in the chalk districts of England. Though chalk is the foundation rock of the country for a considerable extent round Paris, it only rises to the surface in a few situations, being covered by the other strata in the following order:—

1. Chalk and flint.
2. Plastic clay and lower sand.
3. Coarse limestone, or calcaire grossiere.
4. Lower marine sand stone.

In some situations, on the same level with 3, 4, is a bed of calcareous stone penetrated by silex, without shells; it occupies the place of 3 and 4, where it occurs.

6. Lower fresh-water strata.
7. Gypsumous clay, and gypsum containing bones of quadrupeds.
8. A bed of oysters.
9. Sand and sand-stone, without shells.
10. Superior marine sand-stone.
11. Mill-stone without shells and argillaceous sand.
12. Fresh water formation, including marles, mill-stone, and fresh water shells.
13. Alluvial soil, ancient and modern, including pebbles, pudding-stone, black earth *(les marnes argileuses noires)* and peat.

The total thickness of the different beds and strata over the chalk, as given in an ideal section of the country in the 1st tome, is about 150 metres, or near 490 feet. The plaster quarries at Montmartre, in the environs of Paris, are celebrated for their numerous and remarkable organic remains. Montmartre is elevated about eighty yards above the level of the Seine. The summit is covered with vegetable earth, under which is a bed of sand mixed with pebbles of flint. Horizontal strata of marle, earthy limestone, and gypsum, succeed each other. The lowest bed of gypsum in all the rocks of that district is stated by M. Sage to be incumbent on chalk, the gypsum being no deeper than the level of the river. The quarries, he says, may be considered as divided into three large beds; the first, called by the workmen *haute masse*, is often more than fifty feet thick, and is distinctly stratified; it rests on a bed of blueish clay intermixed with marle. The second bed is fourteen feet thick in contiguous strata; this also rests on marle. The third bed, called *basse carriere*, is about fourteen feet thick, but divided into six strata, separated by layers of marle. The lowest is on a level with the plain. The following extract from the Journal de Physique, July 1812, contains the inferences which that eminent naturalist Cuvier and his associate Brongniart have drawn from the organic remains of marine and fresh water animals found over each other at this place; they suppose it has been alternately covered by different seas of salt and fresh water.

1. A sea which deposited an enormous mass of chalk, with moluscous animals of a particular species.

2. The sudden variation of this deposition, and the succession of one entirely different, *(d'une toute autre nature)*, which deposited only beds of clay and sand.

The editor of the Journal de Physique observes, that fossil wood is discovered in these beds.

3. Another sea soon succeeded, (or the same returned again), producing new inhabitants; a prodigious quantity of testaceous molusci, different from those in chalk, form thick beds at the bottom of this deposition, which are principally composed of the covering of testaceous molusci, *(des enveloppes testacees)*. This sea soon after returned.

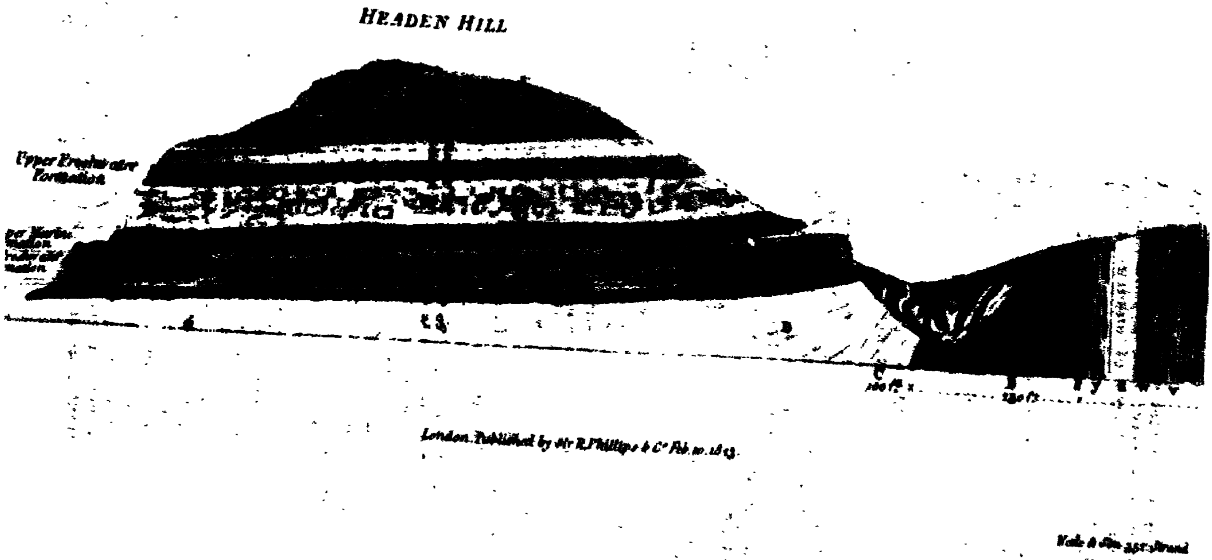
4. The surface was covered with fresh water, *(eau douce)*, and beds were formed alternating with gypsum and marle, which enveloped the debris of animals bred in the lakes, and the bones of those living on its banks.

5th. The salt water returned, and supported first a species of animals with bivalve shells; and others with turbinated shells ("coquilles turbinatées"); these shells ceased to be formed, and were succeeded by oysters. An interval of time elapsed, during which a considerable deposition of sand took place; no animals then existed in these lakes, or their remains have been entirely destroyed.

6th. The various productions of the second lower sea ("la mer inferieure") reappear, and we find on the summit of Montmartre, Romanville, &c. the same shells which occur in the middle of the coarse earthy lime stone ("calcaire grossiere").

7th. At length the sea entirely disappeared for the second time from the lakes, and pools of fresh water ("mares d'eau douce") supplied its place, and covered with their inhabitants almost all the summits of the adjacent banks, and the surface of some of the plains which separated them.

Cuvier and Brongniart further state, that "the lowest beds of gypsum were deposited in a sea analogous to the ocean, because it supported the same animals." In this statement it is assumed that the sea has repeatedly risen and disappeared,


HEADEN HILL
Upper Freshwater Formation
London. Published by Sir R. Phillips & Co. Feb. 10. 1813.

and fresh water has supplied its place, in order to explain the succession of marine and river shells found in the different strata over each other. There is, however, no reason to believe that such a succession of strata exists, except in countries where chalk is found. These strata are local and partial formations. La Metherie, the editor of the Journal de Physique, supposes that these fresh-water shells, and the remains of quadrupeds, were carried by inundations from the land, and deposited in their present situation by marine currents. The succession of marine and fresh-water shells will, it is conceived, admit of a more satisfactory explanation, on the supposition that the south of England was once united to France, and formed the boundary of a mediterranean sea, or lake of fresh water, supplied by the confluence of the great rivers of northern Europe. The banks of this lake, which separated it from the ocean, may have been successively broken down and closed. On the continent of America nature acts upon a magnificent scale. Were her operations attended to, they might illustrate many interesting facts in geology. The lakes of North America are seas of fresh water, more than 1500 hundred miles in circuit: these are placed at a considerable elevation above the Atlantic, and at different levels. They unite by small streights or rivers, which have a rapid descent. On some of them are prodigious waterfalls, which are constantly enlarging and shortening the passage from one to the other, and will ultimately effect the drainage of the upper lakes. The falls of Niagara are well known. The water is divided by a small island which separates the river into two cataracts, one of which is 600, and the other 350 yards wide, and from 140 to 160 feet in depth. It is estimated that 670,000 tons of water are dashed every minute with inconceivable force against the bottom, and are undermining and wearing down the adjacent rocks. Since the banks of the cataract were inhabited by Europeans, they have observed that it is progressively shortening the distance from lake Erie to lake Ontario. When it has worn down the intervening calcareous rocks and effected a junction, the upper lake will become dry land, and form an extensive plain, surrounded by rising ground, and watered by a river or smaller lake, which will occupy the lowest part. In this plain future geologists may trace successive strata of fresh-water formation, covering the subjacent crystalline limestone. The gradual deposition of minute earthy particles, or the more rapid subsidence of mud from sudden inundations, will form different distinct beds, in which will be found remains of fresh-water fish, of vegetables, and of quadrupeds. Large animals are frequently borne along by the rapidity of the current, and precipitated down the cataracts; their broken bones, mixt with calcareous sediment, may form rocks of calcareous tufa where the waters first subside after their descent. Bones of quadrupeds are found thus intermixed in the calcareous rock at Gibraltar. Perhaps there was a period when the branches of Mount Atlas were united with the mountains of Spain, and the Mediterranean mixed its waters with the Atlantic, through a narrow passage like that of Niagara. The two seas would then have a different level, and a stupendous cataract might exist near the rocks of Calpe, and bury under its waves many of the animals that attempted to cross the current. From the intermixture of these bones with calcareous sediment, the present rocks, with their osseous remains, may have originated. These calcareous strata have probably been raised by a sudden subterranean explosion, which opened a passage for the waters of the Atlantic, and reduced both seas to their present level. Such an explosion, nearly in that situation, but less violent, took place in 1755, which shook in the same hour all northern Africa with the southern kingdoms of Europe, and was felt on the distant shores of the American islands.—It has been observed that chalk is principally confined to the coasts of England and France, and to the islands and countries bordering on the German ocean and the Baltic. If the southern parts of England were once united to France, the German ocean would form an extended basin, into which all the waters in the Baltic, with the Rhine

and the principal rivers of northern Europe, would flow. The central parts of England, and the Carpathian mountains, and the mountains in the central parts of France, might form the borders of this lake. If it were nearly closed at its northern extremity, it might be salt in a much less degree than the waters of the ocean, and require different inhabitants from those of the sea or of rivers; and it is not a little remarkable that the animal remains found in chalk differ from those of any other known rock or stratum.—The chalk said to be found in Spain and the south of France, with fresh-water shells over it, may have been formed in similar lakes. Chalk and the strata over it are partial formations principally confined to the northern parts of Europe. They are unknown on the continent of America and other parts of the world.

STRONTIA. About 35 years ago, a mineral was brought to Edinburgh by a dealer in fossils, from a lead mine at Strontian in Argyllshire, which was generally considered as a carbonate of barytes. It has since been found near Bristol, in France, in Sicily, and in Pennsylvania. Dr. Crawford first observed some differences between its solution in muriatic acid, and that obtained from the carbonate of barytes of Anglezark, and thence supposed it to be a new earth. Dr. Hope of Edinburgh had entertained the same opinion, and confirmed it by experiments in 1791. Kirwan, Klaproth, Pelletier, and Sulzer did the same. The carbonic acid may be expelled by a heat of 140° of Wedgwood, leaving the strontia behind, or by dissolving in the nitric acid, and driving this off by heat. Pure strontia is of a greyish-white colour, a pungent acrid taste, and when powdered in a mortar, the dust that rises irritates the lungs and nostrils. Its specific gravity approaches that of barytes. It requires rather more than 160 parts of water at 60 deg. to dissolve it, but of boiling water much less. On cooling, it crystallizes in thin, transparent, quadrangular plates, generally parallelograms, seldom exceeding a quarter of an inch in length, and frequently adhering together. The edges are most frequently bevelled from each side. Sometimes they assume a cubic form. These crystals contain about 68 of water, are soluble in 51·4 times their weight of water at 60 deg., and in little more than twice their weight of boiling water. They give a blood-red colour to the flame of burning alcohol. The solution of strontia changes vegetable blues to a green. Strontia combines with sulphur either in the wet or dry way, and its sulphuret is soluble in water. Sir Humphrey *Davy* decomposed strontia, and found it to consist of oxygen and a metallic base, which he denominated strontium. When strontium is exposed to the air, it rapidly loses its metallic character, by the absorption of oxygen.

STRONTIANITE. Heavy Spar.

STRONTITES. Heavy Spar.

STRONTIUM. The metallic basis of strontia.

STRYCHNIA. A newly discovered vegetable alkali. MM. Pelletier and Caventou, whilst analyzing the vomica nut, and the bean of St. Eustacia, have extracted from these two seeds a substance to which they owe their action on the animal economy. Strychnine is best obtained from St. Ignatius's bean, though it is afforded by some other substances. These seeds are to be reduced to powder by a rasp, and digested in ether, by which a thick oily substance of a faint green colour is obtained, which is transparent when fluid. The ether being withdrawn, the mass is to be treated with alcohol, until all has been extracted that is soluble in that menstruum; this solution is to be filtered cold, and then evaporated, when it leaves a brownish-yellow bitter substance, soluble in water and in alcohol. Both this substance and the oil have a very powerful action on animals, similar to that of the bean itself, due to the strychnine contained in them. To obtain the latter substance pure, a strong aqueous solution of the yellow bitter matter is to be treated with a solution of potass; a precipitate falls, which when washed in cold water is white, crystalline, and extremely bitter. If not perfectly pure, it may be rendered so by solution in acetic or muriatic acid, and re-precipitation by potass or magnesia; if the latter is used, the strychnine may be taken up from it by alcohol. Strychnine may be obtained al-

so from the vomica nut, by infusing it in alcohol, and precipitating the clear solution by sub-acetate of lead in excess. Strychnine is soluble in alcohol, but nearly insoluble in water. At the temperature of 50 deg. Fahrenheit, it requires above 6000 parts for its solution; boiling water dissolves a 2500th part. Its taste is so powerful, that a solution containing the six-hundred-thousandth part, possesses it in a very marked degree. It changes to blue, vegetable colours that have been reddened by acids, and forms neutral salts with the acids. It may be obtained crystallized in minute quadrangular prisms, terminated by low quadrangular pyramids, from a solution in alcohol, containing a little water, by allowing it to crystallize spontaneously. It has no smell. It acts violently on the animal system. It is neither fusible nor volatile, but is decomposed at the temperature of boiling oil into products, consisting of oxygen, hydrogen, and carbon.

SUBERIC ACID. This acid was obtained by Brugnatelli from cork, and afterwards more fully examined by Bouillon la Grange. To procure it, pour on cork grated to powder, six times its weight of nitric acid, of the specific gravity of 1·26, in a tubulated retort, and distil the mixture with a gentle heat, as long as any red fumes arise. As the distillation advances, a yellow matter like wax appears on the surface of the liquid in the retort. While its contents continue hot, pour them into a glass vessel, placed on a sand-heat, and keep them continually stirring with a glass rod, by which means the liquid will gradually grow thicker. As soon as white penetrating vapours appear, let it be removed from the sand-heat, and kept stirring till cold. Thus an orange-coloured mass will be obtained, of the consistence of honey, of a strong sharp smell while hot, and a peculiar aromatic smell when cold. On this, pour twice its weight of boiling water, apply heat till it liquefies, and filter. As the filtered liquor cools, it deposits a powdery sediment, and acquires a thin pellicle. Separate the sediment by filtration, and evaporate the fluid nearly to dryness. The mass thus obtained is the suberic acid, which may be purified by saturating with an alkali, and precipitating by an acid, or by boiling it with charcoal powder.

SUBLIMATION, is a process by which volatile substances are raised by heat, and again condensed in the solid form. This operation is founded on the same principles as distillation, and its rules are the same, as it is nothing but a dry distillation. Therefore all that has been said on the article *Distillation* is applicable here, especially in those cases where sublimation is employed to separate volatile substances from others which are fixed or less volatile. Sublimation is also used in other cases; for instance, to combine volatile matters together, as in the operation of the sublimates of mercury; or to collect some volatile substances, as sulphur, the acid of borax, and all the preparations called flowers. The apparatus for sublimation is very simple. A matrass or small alembic is generally sufficient for the sublimation of small quantities of matter. But the vessels and the method of managing the fire, vary according to the nature of the matters which are to be sublimed, and according to the form which is to be given to the sublimate. The beauty of some sublimates consists in their being composed of very fine, light parts, such as almost all those called flowers; as flowers of sulphur, of benzoin, and others of this kind. When the matters to be sublimed are at the same time volatile, a high cucurbite, to which is adapted a capital, and even several capitals placed one upon another, are employed. The sublimation is performed in a sand-bath, with only the precise degree of heat requisite to raise the substance which is to be sublimed, and the capitals are to be guarded as much as possible from heat. The height of the cucurbite and of the capitals seems well contrived to accomplish this intention. When along with the dry matter which is to be collected in these sublimations, a certain quantity of some liquor is raised, as happens in the sublimation of acid of borax, and in the rectification of volatile concrete alkali, which is a kind of sublimation, a passage and a receiver for these liquors must be provided. This is conveniently done by using the ordi-

nary capital of the alembic, furnished with a beak and a receiver. Some sublimates are required to be in masses as solid and compact as their natures allow. Of this number are camphor, muriate of ammonia, and all the sublimates of mercury. The properest vessels for these sublimations are bottles or matrasses, which are to be sunk more or less deeply in sand, according to the volatility and gravity of the matters that are to be sublimed. In this manner of subliming, the substances having quitted the bottom of the vessel, adhere to its upper part; and as this part is low and near the fire, they there suffer a degree of heat sufficient to give them a kind of fusion. The art, therefore, of conducting these sublimations, consists in applying such a degree of heat, or in so disposing the sand, (that is, making it cover more or less the matrass) that the heat in the upper part of the matrass shall be sufficient to make the sublimate adhere to the glass, and to give it such a degree of fusion as is necessary to render it compact; but at the same time this heat must not be so great as to force the sublimate through the neck of the matrass, and dissipate it. These conditions are not easily to be attained, especially in great works. Many substances may be reduced into flowers, and sublimed, which require for this purpose a very great heat, with the access of free air, and even the contact of coals, and therefore cannot be sublimed in close vessels. Such are most roots or flowers of metals, and even some saline substances. When these sublimates are required, the matters from which they are to be separated must be placed among burning coals in open air; and the flowers are collected in the chimney of the furnace in which the operation is performed. The tutty, calamine, or pompholix, collected in the upper part of furnaces in which ores are smelted, are substances of this kind.

SUBSALT. A salt having an excess of base beyond what is requisite for saturating the acid, as supersalt is one with an excess of the acid. Thus, sulphate of potash is the neutral compound of sulphuric acid and potash; subsulphate of potash, a compound of the same ingredients, in which there is an excess of base; supersulphate of potash, a compound of the same acid and the same base, in which there is an excess of acid. The term was introduced by Dr. Pearson.

SUCCINATES. Compounds of succinic acid with the salifiable bases.

SUCCINIC ACID. It has long been known that amber, when exposed to distillation, affords a crystallized substance, which sublimes into the upper part of the vessel. Before its nature was understood it was called salt of amber; but it is now known to be a peculiar acid, as Boyle first discovered. The crystals are at first contaminated with a little oil, which gives them a brownish colour; but they may be purified by solution and crystallization, repeated as often as necessary, when they will become transparent and shining. Pott recommends to put on the filter through which the solution is passed, a little cotton previously wetted with oil of amber. Their figure is that of a triangular prism. Their taste is acid, and they redden the blue colour of litmus, but not that of violets. They are soluble in less than two parts of boiling alcohol, in two parts of boiling water, and in twenty-five of cold water. M. Planche of Paris observes, that a considerable quantity might be collected in making amber varnish, as it sublimes while the amber is melting for this purpose, and is wasted.

SUGAR, is a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, skirret, parsnips, and dried grapes. The process of this chemist consisted in digesting these roots, rasped, or finely divided, in alcohol. This fluid dissolves the sugar, and leaves the extractive matter untouched, which falls to the bottom. In Canada, the inhabitants extract sugar from the maple. At the commencement of spring, they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice afford by evaporation fifteen of a brownish sugar. The quantity prepared an-

nually amounts to fifteen thousand weight. Dr. Rush, in the Transactions of the American Philosophical Society, vol. iii. has given an account at length, of the sugar maple tree, of which the following is a short abstract.—The acer saccharinum of Linnæus, or sugar maple tree, grows in great quantities in the western counties of all the middle States of the American Union. It is as tall as the oak, and from two to three feet in diameter; puts forth a white blossom in the spring, before any appearance of leaves; its small branches afford sustenance for cattle, and its ashes afford a large quantity of excellent potash. Twenty years are required for it to attain its full growth. Tapping does not injure it; but, on the contrary, it affords more syrup, and of a better quality, the oftener it is tapped. A single tree has not only survived, but flourished, after tapping, for forty years. Five or six pounds of sugar are usually afforded by the sap of one tree; though there are instances of the quantity exceeding twenty pounds. The sugar is separated from the sap either by freezing, by spontaneous evaporation, or by boiling. The latter method is the most used. Dr. Rush describes the process; which is simple, and practised without any difficulty by the farmers. From frequent trials of this sugar, it does not appear to be in any respect inferior to that of the West Indies. It is prepared at a time of the year when neither insect nor the pollen of plants, exists to vitiate it, as is the case with common sugar. From calculations grounded on facts, it is ascertained, that America is now capable of producing a surplus of one eighth more than its own consumption; that is, on the whole, about 135,000,000 pounds; which, in the country, may be valued at fifteen pounds weight for one dollar. The Indians likewise extract sugar from the pith of the bamboo. The beet has lately been much cultivated in Germany, for the purpose of extracting sugar from its root. For this the roots are taken up in autumn, washed clean, wiped, sliced lengthwise, strung on threads, and hung up to dry. From these the sugar is extracted by maceration in a small quantity of water; drawing off this upon fresh roots, and adding fresh water to the first roots, which is again to be employed the same way, so as to get out all their sugar and saturate the water as much as possible with it. This water is to be strained and boiled down for the sugar. Some merely express the juice from the fresh roots, and boil this down; others boil the roots; but the sugar extracted in either of these ways is not equal in quality to the first. Professor Lampadius obtained from 110lbs. of the roots, 4lbs. of well grained white powder sugar; and the residuums afforded seven pints of a spirit resembling rum. Achard says, that about a ton of roots produced him a 100lbs. of raw sugar, which gave 55lbs. of refined sugar, and 25lbs. of treacle. But the sugar which is so universally used, is afforded by the sugar cane (arundo saccharifera), which is raised in our colonies. When this plant is ripe it is cut down, and crushed by passing it between iron cylinders placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called in the French sugar colonies *vesou*; and the cane, after having undergone this pressure, is call d *begasse*. The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous. The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the scum as it rises. In this state it is called syrup; and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the cooler. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterward poured into casks to accelerate its cooling; and while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottom with several holes stoped with cane. The syrup

which is not condensed filters through these canes into the cistern beneath; and leaves the sugar in the state called *coarse sugar*, or *muscovado*. This sugar is yellow and fat, and is purified in the islands in the following manner:—The syrup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay moistened with water. This water filters through the mass, carrying the syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called fine syrup. Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterward taken out, and dried in a stove for eight or ten days; after which they are pulverised, packed, and exported to Europe, where they are still farther purified. The operation of the French sugar refiners consists in dissolving the cassonade, or clayed sugar, in lime water. Bullocks' blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminished, and the scum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in to moderate its agitation. When the boiling is sufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the syrup together with *the grain sugar* already formed. When the whole is cold, the moulds are opened and the loaves are covered with moistened clay, which is renewed from time to time till the sugar is well cleansed from its syrup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to 145 deg. F. They remain in this stove eight days, after which they are wrapped in blue paper for sale. The several syrups, treated by the same methods, afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of molasses. The Spaniards use these molasses in the preparation of sweetmeats. A solution of sugar, much less concentrated than that we have just been speaking of, lets fall by repose crystals, which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of sugar-candy. The preceding account of the manufacture of sugar in the colonies is chiefly extracted from Chaptal. The following is taken from Edwards' History of the West Indies, the authority of which is indubitable. Such planters as are not fortunately furnished with the means of grinding their canes by water, are at this season frequently impeded by the failure or insufficiency of their mills; for though a sugar mill is a very simple contrivance, yet great force is requisite to make it vanquish the resistance which it necessarily meets with. It principally consists of three upright iron rollers or cylinders, from thirty to forty inches in length, and from twenty to twenty-five inches in diameter; and the middle one to which the moving power is applied, turns the other two by means of cogs. The canes, which are previously cut short and tied into bundles, are twice compressed between these rollers; for after they have passed through the first and second rollers, they are turned round the middle one by a piece of frame work of a circular form, which is called, in Jamaica, the dumb returner, and forced back through the second and third. By this operation they are squeezed completely dry, and sometimes even reduced to powder. The cane-juice is received in a leaden bed, and thence conveyed into a vessel called the receiver. The refuse, or macerated rind of the cane, which is called cane-trash, serves for fuel to boil the liquor. The juice from the mill usually contains eight parts of pure water, one part of sugar, and one part made up of gross oil and mucilage, with a portion of essential oil. The proportions are taken at a medium; for some juice has been so rich as to

make a hogshead or sixteen hundred weight of sugar from thirteen hundred gallons, and some is so watery as to require more than double that quantity. The richer the juice is, the less it abounds with redundant oil and gum; so that very little knowledge of the contents of any other quantity can be obtained by the most exact analysis of any one quantity of juice.

The following matters are likewise usually contained in cane-juice. Some of the green tops, which serve to tie the canes in bundles, are often ground in, and yield a raw acid juice exceedingly disposed to ferment and render the whole liquor sour. Beside these they grind in some pieces of the ligneous part of the cane, some dirt, and lastly, a substance of some importance, which may be called the crust. This substance is a thin black coat of matter that surrounds the cane between the joints, beginning at each joint, and gradually growing thinner the farther from the joint upwards, till the upper part between the joints appears entirely free from it, and resumes its bright yellow colour. It is a fine black powder, that mixes with the clammy exudations from the cane; and as the fairness of the sugar is one symptom of its goodness, a small quantity of this crust must very much prejudice the commodity. The sugar is obtained by the following process: The juice or liquor runs from the receiver to the boiling-house, along a wooden gutter lined with lead. In the boiling-house, it is received into one of the copper pans or caldrons called clarifiers. Of these there are generally three; and their dimensions are determined by the power of supplying them with liquor. There are water-mills that will grind with great facility sufficient for thirty hogsheads of sugar in a week. Methods of quick boiling cannot be dispensed with on plantations thus fortunately provided; for otherwise the cane liquor would unavoidably become tainted before it could be exposed to the fire. The purest cane juice will not remain twenty minutes in the receiver without fermenting. Hence, clarifiers are sometimes seen of one thousand gallons each. But on plantations that, during crop time, make from fifteen to twenty hogsheads of sugar a-week, three clarifiers of three or four hundred gallons each are sufficient. The liquor, when clarified, may be drawn off at once, with pans of this size, and there is leisure to cleanse the vessels every time they are used. Each clarifier is furnished either with a siphon or cock for drawing off the liquor. It has a flat bottom, and is hung to a separate fire, each chimney having an iron slider, which, when shut, causes the fire to be extinguished through want of air. As soon as the stream from the receiver has filled the clarifier with fresh liquor, and the fire is lighted, the temper, which is generally Bristol white-lime in powder, is stirred into it This is done, in order to neutralize the superabundant acid, and to get rid of which is the greatest difficulty in sugar-making. Alkali or lime, generally effects this; and at the same time part of it is said to become the basis of the sugar. Mr. Edwards affirms, that it affects both the smell and taste of the sugar. It falls to the bottom of the pans in a black insoluble matter, which scorches the bottom of the vessels, and cannot without difficulty be detached from them. But, in order that less of the lime may be precipitated to the bottom, little more than half a pint of Bristol lime should be allowed to every hundred gallons of liquor, and Mr. Bousie's method of dissolving it in boiling water previous to mixing it with the cane-juice should be adopted. As the force of the fire increases, and the liquor grows hot, a scum is thrown up, which is formed of the gummy matter of the cane, with some of the oil, and such impurities, as the mucilage is able to entangle. The heat is now suffered to increase gradually till it nearly rises to the heat of boiling water. The liquor, however, must by no means be suffered to boil. When the scum begins to rise into blisters, which breaks into white froth, and generally appear in about forty minutes, it is known to be sufficiently heated. Then the damper is applied, and the fire extinguished; and, if circumstances will admit, the liquor after this is suffered to remain a full hour undisturbed. In the next place, it is carefully drawn off, either by a siphon which draws up the clear fluid

through the scum, or by means of a cock at the bottom. In either case, the scum sinks down without breaking as the liquor flows; for its tenacity prevents any admixture. The liquor is received into a gutter or channel, which conveys it to the evaporating boiler, commonly called the grand copper; and if produced at first from good and untainted canes, it will then appear almost transparent. In the grand or evaporating copper, which should be sufficiently large to receive the net contents of one of the clarifiers, the liquor is suffered to boil, and the scum, as it rises, is continually taken off by large scummers, till the liquor becomes finer and somewhat thicker. This operation is continued, till the subject is so reduced in quantity, that it may be contained in the next or second copper, into which it is then ladled. The liquor is now almost of the colour of Madeira wine. In the second copper the boiling and scumming are continued; and if the subject be not so clean as is expected, lime-water is thrown into it. This addition not only serves to give more temper, but likewise to dilute the liquor, which sometimes thickens too fast to permit the feculencies to rise in the scum. When the froth in boiling arises in large bubbles, and is not much discoloured, the liquor is said to have a favourable appearance in the second copper. When, in consequence of such scumming and evaporation, the liquor is again so reduced, that it may be contained in the third copper, it is ladled into it, and so on to the last copper, which is called the teache. This arrangement supposes four boilers or coppers, besides the three clarifiers. In the teache the subject undergoes another evaporation, till it is supposed boiled enough to be removed from the fire. This operation is usually called striking, *i. e.* ladling the liquor, which is now exceeding thick, into the cooler. The cooler, of which there are generally six, is a shallow wooden vessel, about eleven inches deep, seven feet in length, and from five to six feet wide. A cooler of this size holds a hogshead of sugar. Here the sugar grains, *i. e.* as it cools, it runs into a coarse irregular mass of imperfect crystals, separating itself from the molasses. From the cooler it is taken to the curing-house, where the molasses drains from it. But here it may be proper to notice the rule for knowing when the subject is fit to be ladled from the teache to the cooler. Many of the negro boilers, from long habit, guess accurately by the eye alone, judging by the appearance of the grain on the back of the ladle; but the practice generally adopted, is to judge by what is called the touch, *i. e.* taking up with the thumb a small portion of the hot liquor from the ladle, and as the heat diminishes, drawing with the fore finger the liquid into a thread. This thread will suddenly break and shrink from the thumb to the suspended finger, in different lengths, according as the liquor is more or less boiled. A thread of a quarter of an inch long generally determines the proper boiling height for strong muscovado sugar. The curing-house is a large airy building, provided with a capacious molasses cistern, the sides of which are sloped and lined with terras or boards. A frame of massy joist-work without boarding, is placed over this cistern; and empty hogsheads without headings are ranged on the joints of this frame. Eight or ten holes are bored in the bottoms of these hogsheads, and through each of the holes the stalk of a plantain leaf is thrust six or eight inches below the joists, and long enough to stand upright above the top of the hogshead. Into these hogheads the mass from the cooler is put, which is called potting; and the molasses drains through the spongy stalk, and drops into the cistern, whence it is occasionally taken for distillation. In the space of three weeks, the sugar becomes tolerably dry and fair. It is then said to be cured, and the process is finished. Sugar thus obtained is called muscovado, and is the raw material whence the British sugar-bakers chiefly make their loaf or refined lump. There is another sort, which was formerly much used in Great Britain for domestic purposes, and was generally known by the name of Lisbon sugar. In the West Indies it is called clayed sugar; and the process of making it is as follows:—A quantity of sugar from the cooler is put into conical pots or pans, which the French call formes, with the points downwards,

having a hole about half an inch in diameter at the bottom, for the molasses to drain through, but which at first is closed with a plug. As soon as the sugar in these pots is cool, and becomes a fixed body, which is known by the middle of the top falling in, the plug is taken out, and the pot placed over a large jar, intended to receive the syrup or molasses that drain from it. In this state it is left as long as the molasses continue to drop, when a stratum of clay is spread on the sugar, and moistened with water. This, imperceptibly oozing through the pores of the clay, dilutes the molasses, in consequence of which more of it comes away than from sugar cured in the hogshead, and the sugar of course becomes so much whiter and purer. According to Sloane, the process was first discovered in Brazil, by accident: "A hen," says he, "having her feet dirty, going over a pot of sugar, it was found under her feet to be whiter than elsewhere." The reason assigned why this process is not universally adopted in the British sugar islands, is this, that the water which dilutes and carries away the molasses, dissolves and carries with it so much of the sugar, that the difference in quality does not pay for the difference in quantity. It is probable, however, that the French planters are of a different opinion; for upwards of four hundred of the plantations of St. Domingo have the necessary apparatus for claying, and actually carry on the system. Sugar is very soluble in water, and is a good medium for uniting that fluid with oily matters. It is much used for domestic purposes, and appears on the whole to be a valuable and wholesome article of food, the uses of which are most probably restricted by its high price. This price may in a certain degree arise from the nature of the article and its original cost; but is no doubt in a great measure owing to the inhuman and wasteful culture by slaves, and the absurd principles of European colonization, duties, drawbacks, and bounties, which have the effect to create unnatural monopolies, and to prevent commerce from finding its level. This is eminently the case with regard to our West-India islands, and their produce. It appears that sugar has the propery of rendering some of the earths soluble in water. This property was accidently discovered by Mr. William Ramsay of Glasgow. Being employed in making experiments on sugar, and happening to put some quicklime into a cold solution of it, he noticed that it had acquired an uncommon caustic taste. Hence he concluded, that sugar possesses the property of dissolving a certain proportion of lime; and in order to ascertain its capacity in this respect, experiments were made upon this earth, together with strontites, magnesia, and barytes. Sugar, dissolved in water at the temperature of 50 deg. is capable of dissolving one-half of its weight of lime. The solution of lime in sugar is of a beautiful white-wine colour, and has the smell of fresh slaked quicklime. It is precipitated from the solution, by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed, by double affinity, by caustic and carbonated potash and soda, the citrate, tartrate, and oxalate of potash, &c. An equal weight of strontia, with the sugar employed, is capable of being dissolved at the temperature of 212 deg., and of being retained in solution by the sugar at 50 deg. of Fahrenheit. On exposing the crystals, which had fallen down during the cooling of the liquid, to the air of the atmosphere, they attracted carbonic acid, and effloresced. The solution of strontia in sugar is of a fine white-wine colour, and, like that o lime, has a peculiar caustic smell. This earth is precipitated by caustic and carbonated potash and soda; also by the carbonic, citric, tartaric, sulphuric, and oxalic acids; and it is decomposed by compound affinity, by the carbonates of potash and soda, also by the citrate, tartrate, and oxalate of potash. The solution of magnesia in syrup, like those of lime and strontia, was of a pure white colour, and had no sensible variation in smell or taste from the common solution of sugar, farther than that the sweet seemed much improved, and was softer and more agreeable to the palate, as if it were entirely freed from the earthy taste, which unrefined sugar frequently has. On its remaining at rest for some months in a bot-

tle well corked, the magnesia appears to be entirely separated. Very little alumina is dissolved by a solution of sugar, when fresh precipitated earth is presented to it, either in the cold or hot state. The union of sugar with the alkalis has been long known; but this is rendered more strikingly evident, by carbonated potash or soda, for instance, decomposing the solutions of lime and strontia in sugar, by double affinity. In making solutions of unrefined sugar for culinary purposes, a grey-coloured substance is found frequently precipitated. It is probable that this proceeds from a superabundance of lime which has been used in clarifying the juice of the sugar-cane at the plantations abroad. Sugar with this imperfection, is known among the refiners of this article by the name of weak. And it is justly termed so, the precipitated matter being nothing but lime which has attracted carbonic acid from the sugar, (of which there is a great probability), or from the air of the atmosphere. A bottle in which was kept a solution of lime in sugar for at least four years, closely corked, was entirely incrusted with a yellowish-coloured matter, which on examination was found to be entirely carbonate of lime. Sugar is known to be a very powerful anti-septic, and though it is employed in making hams, in which it is one of the most active substances in preserving; it is deserving of a more extensive application, as it does not, like salt, destroy the provisions, and is itself nutritious. Fish may be preserved in a dry state, and perfectly fresh, by means of sugar alone, and even a very small quantity of it. Fresh fish may be kept some days, and when boiled be as if just caught. If dried and kept free from mouldiness, there seems no limit to their preservation; and they are much better in this way, than when salted. This process is particularly valuable in making what is called kippered salmon, which, when thus prepared, are superior in flavor and quality to those which are salted or smoked. It is barely necessary to open the fish, and apply sugar to the muscular part, placing it in a horizontal position for two or three days, that the sugar may penetrate. After this it may be dried; and it is only further necessary to wipe and ventilate it occasionally to prevent mouldiness. A table spoonful of brown sugar is sufficient for a salmon of five or six pounds, and if a salt flavor be desired, the same quantity may be added.

SUGAR OF LEAD. Acetates of lead.

SULPHATES. Definite compounds of sulphuric acid with the salifiable bases.

SULPHITES. Definite compounds of sulphurous acid with the bases.

SULPHUR, is a well known substance, sold in the form of a powder or in solid pieces, when it is called brimstone. It is found in the neighbourhood of volcanoes: in the tract of land between Naples and the ancient Baiæ, called Solfa-terra, the smoking plains, the remnant of a half-extinguished volcano, it is found in great abundance. Sulphur is brought in large quantities to this country from Mount Etna in Sicily, but is to be found in greater or less quantities near all volcanoes, of which the number throughout the world is very great. Sulphur is often found in coal mines, and indeed the common coal in our fires more or less contains this mineral. It is often found combined with iron, copper, and other metals, when it is called pyrites. When purified from other matter, its specific gravity is about 1·990. When sulphur is heated to about 180° of Fahrenheit, it sends off fumes, and its odour is well known and very suffocating. It is employed to force foxes and badgers from their holes. At 225° sulphur melts, between 350° and 400° it becomes viscid and of a brown colour, and at 600° it rises in fine powder. When slowly cooled it forms a fine fibrous crystalline mass, and as it cools from the arrangement of the particles in crystals, it occupies more bulk in the same manner, and for the same reason as ice is lighter than liquid water. Sulphur suffers no change by exposure to the air. It is not soluble in water, but it may be dissolved in a small quantity in oil or spirit of wine. Put some spirit of wine into a retort, and a small quantity of powdered sulphur, and hold the retort over a lamp or candle, in order to cause the spirit to rise in vapour, or in other words to distil it. Let the spirit which comes

off by distillation be poured into a clear glass, and add to it water, sulphur will be precipitated to the bottom, which will prove that some had been dissolved by the spirit. Sulphur has from time immemorial been employed in producing a fine white colour in wool or silk. The effect may be seen by holding a piece of flannel near the flames of a few brimstone matches: a far more beautiful experiment is to take a red rose, and hold it near the fumes of some burning brimstone matches, and it immediately becomes white. Sulphur is often found in a state of nature, combined with soda potass and the earths. Such bodies may be formed by art, by melting the sulphur and mixing the alkali or earth with it, when in a state of fusion. Sulphur is often employed for taking off impressions from seals, medals, and coins: it is melted at a heat from 300° to 350°, and poured into water, when it is of a reddish colour and soft as wax: in this state the impressions are made, and the sulphur in a short time becomes hard, and as it is not affected by air and moisture, it is exceedingly well adapted for preserving the impressions unaltered for a great length of time. Sulphur is used in bleaching and dyeing. In medicine it it is employed with the most beneficial effect. It is used to close the seams of casks, from which water may be oozing out, for which it is well adapted, as it is insoluble in that liquid. Its great inflammability renders it extremely useful in one of the most ordinary purposes in striking a light, either by means of a tinder box, or a box containing a preparation of phosphorus. The most important purpose to which it is applied, is in the composition of gunpowder, as by its inflammability a quantity of gunpowder is set on fire in a moment, and the effect of gunpowder depends on the whole exploding at once, and at one powerful effort propelling all before it. The component parts of gunpowder are sulphur, charcoal or carbon, and saltpetre or nitrate of potass. These must be ground exceedingly fine separately, one from another. As the use of iron would be exceedingly dangerous, the machinery must all be made of wood and copper, and even with every possible care there is much danger in the operation. The ingredients must be wetted and mixed together in a certain proportion, and by another operation, made to form into grains of powder. The drying of these is still more dangerous than the preceding operations. The heat of the sun is quite insufficient, and it is required to produce a great heat and yet avoid making any sparks, which might blow all up at once. This is effected by a piece of iron which communicates with a fire in another apartment, and the heat coming gradually along this iron, raises the temperature of the room sufficiently to dry the powder, so that if no dust rise from the powder and fall upon this iron, no evil will ensue. Sulphur combines with oxygen and forms different acids. See *Sulphuric and Sulphurous Acids*. It combines with hydrogen, forming sulphuretted hydrogen. The usual way of preparing it is to pour dilute sulphuric acid or muriatic acid on the black sulphuret of iron or antimony, in a retort. It may be collected through mercury, where accurate experiments are to be made. It burns when a lighted taper is brought near it, with a pale blue flame, and deposits sulphur. It has the smell of rotten eggs. It is absorbed by water, which takes up more than an equal volume of the gas. It is very deleterious to animal life. It unites with alkalis and oxides, forming hydrosulphurets. Sulphuretted hydrogen, sulphur, and the alkalis, have the property of forming very variable triple compounds, which contain less sulphuretted hydrogen than the hydrosulphurets. These have been called sulphuretted hydro-sulphurets; but the name of hydrogenated sulphurets has been given to those combinations which have been saturated with sulphur at a high temperature. They are sometimes called hydroguretted sulphurets.

SULPHURETTED CHYAZIC ACID. Sulphuro prussic acid.

SULPHURIC ACID. When sulphur is heated to 180° or 190° in an open vessel, it melts, and soon afterward emits a blueish flame, visible in the dark, but which, in open daylight, has the appearance of a white fume. The flame has a suffocating smell, and has so little heat, that it will not set fire to flax, or even gunpowder, so that in this way the sul-

phur may be entirely consumed out of it. If the heat be still augmented, the sulphur boils, and suddenly bursts into a much more luminous flame, the same suffocating vapour still continuing to be emitted. The suffocating vapour of sulphur is imbibed by water, with which it forms the fluid formerly called volatile vitriolic, now sulphurous acid. If this fluid be exposed for a time to the air, it loses the sulphureous smell it had at first, and the acid becomes more fixed. It is then the fluid which was formerly called the spirit of vitriol. Much of the water may be driven off by heat, and the dense acid which remains is the sulphuric acid, commonly called oil of vitroil: a name which was probably given to it from the little noise it makes when poured out, and the unctuous feel it has when rubbed between the fingers, produced by its corroding and destroying the skin, with which it forms a soapy compound. The stone or mineral called martial pyrites, which consists for the most part of sulphur and iron, is found to be converted into the salt called green vitriol, but more properly sulphate of iron, by exposure to air and moisture. In this natural process the pyrites break and fall into pieces; and if the change take place rapidly, a considerable increase of temperature follows, which is sometimes sufficient to set the mass on fire. By conducting this operation in an accurate way, it is found that oxygen is absorbed. The sulphate is obtained by solution in water, and subsequent evaporation; by which the crystals of the salt are separated from the earthy impurities, which were not suspended in the water. The sulphuric acid was formerly obtained in this country by distillation from sulphate of iron, as it still is in many parts abroad, the common green vitriol is made use of for this purpose, as it is to be met with at a low price, and the acid is most easily to be extracted from it. With respect to the operation itself, the following particulars should be attended to: first, the vitriol must be calcined in an iron or earthen vessel, till it appears of a yellowish red colour: by this operation it will lose half its weight. This is done in order to deprive it of the greater part of the water which it has attracted into its crystals during the crystallization, and which would otherwise, in the ensuing distillation, greatly weaken the acid. As soon as the calcination is finished, the vitriol is to be put immediately, while it is warm, into a coated earthen retort, which is to be filled two-thirds with it, so that the ingredients may have sufficient room upon being distended by the heat, and thus the bursting of the retort be prevented. It will be most adviseable to have the retort immediately enclosed in brick-work in a reverberatory furnace, and to stop up the neck of it till the distillation begins, in order to prevent the materials from attracting fresh humidity from the air. At the beginning of the distillation, the retort must be opened, and a moderate fire is to be applied to it, in order to expel from the vitriol all that part of the phlegm which does not taste strongly of the acid, and which may be revived in an open vessel placed under the retort. But as soon as there appear any acid drops, a receiver is to be added, into which has been previously poured a quantity of the acidulous fluid which has come over, in the proportion of half a pound of it to twelve pounds of the calcined vitriol; when the receiver is to be secured with a proper luting. The fire is now to be raised by little and little, to the most intense degree of heat, and the receiver carefully covered with wet cloths, and, in winter time, with snow or ice, as the acid rises in the form of a thick white vapour, which, toward the end of the operation becomes hot, and heats the receiver to a great degree. The fire must be continued at this high pitch for several days, till no vapour issues from the retort, nor any drops are seen trickling down its sides. In the case of a great quantity of vitriol being distilled, M. Bernhardt has observed it to continue emitting vapours in this manner for the space of ten days. When the vessels are quite cold, the receiver must be opened carefully, so that none of the luting may fall into it: after which the fluid contained in it is to be poured into a bottle, and the air carefully excluded. The fluid that is thus obtained is the German sulphuric acid, of which Bernhardt got sixty-four pounds from six hundred weight of vitriol; and on the other hand when no water had been previously poured into the receiver, fifty-two

pounds only of a dry concrete acid. This acid was formerly called glacid oil of vitriol, and its consistence is owing to a mixture of sulphurous acid, which occasions it to become solid at a moderate temperature. The sulphuric acid made in Great Britain is produced by the combustion of sulphur. There are three conditions requisite in this operation. Oxygen must be present to maintain the combustion; the vessel must be so close as to prevent the escape of the volatile matter which rises, and water must be present to imbibe it. For these purposes, a mixture of eight parts of sulphur with one of nitre is placed in a proper vessel, enclosed within a chamber of considerable size, lined on all sides with lead, and covered at bottom with a shallow stratum of water. The mixture being set on fire, will burn for a considerable time by virtue of the supply of oxygen which nitre gives out when heated, and the water imbibing the sulphurous vapours, becomes gradually more and more acid after repeated combustions, and the acid is afterward concentrated by distillation. That the nitre supplies but a very small portion of the oxygen, has been shown by MM. Clement and Desormes; for 100 parts of nitre, with a proper supply of sulphur, will yield 2000 parts of sulphuric acid, which contain 1200 of oxygen; and after the burning of the nitre, it is converted into the sulphate and bisulphate of potass, which contain about as much oxygen as the nitre originally did. It is a question then whence the oxygen of the acid is obtained. These chemists suppose, that in the process, nitrous and nitric acids in the vapour are displaced from the nitre, which are decomposed by the sulphurous acid into nitrous gas and deutoxide of azote. This gas being heated, becomes a little lighter than air, and rises to the top of the chamber to an aperture which the manufacturers had always been obliged to leave open, or the process of acidification would not go on. This nitrous vapour coming in contact with the air, absorbs oxygen, becomes nitrous acid vapour, an heavy aeriform body, which immediately precipitates on the sulphurous flame, and is changed into sulphuric acid; whilst itself again taking the form of nitrous gas, reascends to the aperture, and descends with fresh oxygen as before. Sir H. Davy found that the presence of water was necessary in this process. The sulphuric acid of commerce contains about 7 parts in 1000 of foreign saline matter of sulphate of potash and lead; from which it may be freed by distillation. Genuine commercial sulphuric acid should not be weightier than 1·8485, or there is reason to suspect adulteration. The sulphuric acid strongly attracts water, which it takes from the atmosphere very rapidly, and in larger quantities if suffered to remain in an open vessel, imbibing one-third of its weight in twenty-four hours, and more than six times its weight in a twelve-month. If four parts by weight be mixed with one of water at 50°, they produce an instantaneous heat of 300° F.; and four parts raise one of ice to 212°: on the contrary, four parts of ice, mixed with one of acid, sink the thermometer to 4° below 0. When pure, it is colourless, and emits no fumes. It requires a great degree of cold to freeze it; and if diluted with half a part or more of water, unless the dilution be carried very far, it becomes more and more difficult to congeal; yet at the specific gravity of 1·78, or a few hundredths above or below this, it may be frozen by surrounding it with melting snow. Its congeliation forms regular prismatic crystals with six sides. Its boiling point, according to Bergman, is 540°; according to Dalton, 590°. Sulphuric acid has been called oil of vitriol from its oily consistence. All simple combustibles decompose it. At 400° of Fahrenheit, sulphuric acid is converted with sulphur into sulphurous acid. The sulphuric acid is of very extensive use in the art of chemistry, as well as in metallurgy, bleaching, and some of the processes for dyeing, in medicine it is given as a tonic, stimulant, and lithontriptic, and sometimes used externally as a caustic. The combinations of this acid with the various bases, are called sulphates, and most of them have long been known by various names. With barytes it is found native and nearly pure in various forms, in coarse powder, rounded masses, stalactites, and regular crystallizations, which are in some lamellar, in others needly, in others pris-

matic or pyramidal. The cawks of our country and the Bolognian stone are merely native sulphates of barytes. Their colour varies considerably, as well as their figure, but their specific gravity is great, that of a very impure kind being 3·89, and the pure sorts varying from 4 to 4·865; hence it has been distinguished by the names of marmor metallicum and ponderous spar. This salt, though deleterious, is less so than the carbonate of barytes, and is more economical for preparing the muriate for medicinal purposes. It requires 43,000 parts of water to dissolve it at 60°. Sulphate of strontian has a considerable resemblance to that of barytes in its properties. It is found native in considerable quantities at Aust Passage and other places in the neighbourhood of Bristol. It requires 3840 parts of boiling water to dissolve it. The sulphate of potash, vitriolated kali of the London college, formerly vitriolated tartar, sal de duobus, and arcanum duplicatum, crystallizes in hexaëdral prisms, terminated by hexagonal pyramids, but susceptible of variations. Its crystallization by quick cooling is confused. Its taste is bitter, acrid, and a little saline. It is soluble in 5 parts of boiling water, and 16 parts at 60°. In the fire it decrepitates, and is fusible by a strong heat. It is decomposable by charcoal at a high temperature. It may be prepared by direct mixture of its component parts; but the usual and cheapest mode is to neutralize the acidulous sulphate left after distilling nitric acid, the sal enixum of the old chemists, by the addition of carbonate of potash. The sal polychrest of old dispensatories, made by deflagrating sulphur and nitre in a crucible, was a compound of the sulphate and sulphite of potash. The acidulous sulphate is sometimes employed as a flux, and likewise in the manufacture of alum. In medicine, the neutral salt is sometimes used as a deobstruent, and in large doses as a mild cathartic; dissolved in a considerable portion of water, and taken daily in such quantity as to be gently aperient, it has been found serviceable in cutaneous affections, and is sold in London for this purpose as a nostrum; and certainly it deserves to be distinguished from the generality of quack medicines, very few indeed of which can be taken without imminent hazard. The sulphate of soda is the vitriolated natron of the college, the well known Glauber's salt, or sal mirabile. It is commonly prepared from the residuum left after distilling muriatic acid, the superfluous acid of which may be saturated by the addition of soda, or precipitated by lime, and is likewise obtained in the manufacture of the muriate of ammonia. (See *Ammonia*.) Scherer mentions another mode by Mr. Funcke, which is, making 8 parts of calcined sulphate of lime, 5 of clay, and 5 of common salt, into a paste with water, burning this in a kiln, and then powdering, lixiviating, and crystallizing. It exists in large quantities under the surface of the earth in some countries, as Persia, Bohemia, and Switzerland; it is found mixed with other substances in mineral springs and sea water, and sometimes effloresces on walls. Sulphate of soda is bitter and saline to the taste. It is soluble in 2·85 parts of cold water, and 0·8 at a boiling heat, it crystallizes in hexagonal prisms bevelled at the extremities, sometimes grooved longitudinally, and of very large size when the quantity is great: these effloresce completely into a white powder if exposed to a dry air, or even if kept wrapped up in paper in a dry place; yet they retain sufficient water of crystallization to undergo the aqueous fusion on exposure to heat, but by urging the fire, melt. Barytes and strontian take its acid from it entirely, and potash partially: the nitric and muriatic acids, though they have a weaker affinity for its base, combine with a part of it when digested on it. Heated with charcoal, its acid is decomposed. As a purgative, its use is very general; and it has been employed to furnish soda. Pajot des Charmes has made some experiments on it in fabricating glass; with sand alone it would not succeed, but equal parts of carbonate of lime, sand, and dried sulphate of soda, produced a clear, solid, pale, yellow glass. Sulphate of lime, selenite, gypsum, plaster of Paris, or sometimes alabaster, forms extensive strata in various mountains. The specular gypsum, or glacies *Mariæ*, is a species of this salt, and affirmed by some French travellers to be employed in Russia,

where it abounds, as a substitute for glass in windows. Its specific gravity is from 1·872 to 2·311. It requires 500 parts of cold water, and 450 of hot to dissolve it. When calcined it decrepitates, becomes very friable and white, and heats a little with water, with which it forms a solid mass. In this process it loses its water of crystallization. In this state it is found native in Tyrol, crystallized in rectangular parallelopipeds, or octaëdal or haxaëdral prisms, and is called anhydrous sulphate of lime. Both the natural and artificial anhydrous sulphate consists of 56·3 lime and 43·6 acid, according to Mr. Chenevix. The calcined sulphate is much employed for making casts of anatomical and ornamental figures; as one of the bases of stucco; as a fine cement for making close and strong joints between stone, and joining rims or tops of metal to glass; for making moulds for the Staffordshire potteries; for cornices, mouldings, and other ornaments in building. For these purposes, and for being wrought into columns, chimney pieces and various ornaments, about eight hundred tons are raised annually in Derbyshire, where it is called alabaster. In America, it is laid on grass land as a manure. Sulphate of magnesia, the vitriolated magnesia of the late, and sal catharticus amarus of former, London Pharmacopœias, is commonly known by the name of Epsom salt, as it was furnished in considerable quantity by the mineral water at that place, mixed however with a considerable portion of sulphate of soda. It is afforded, however, in greater abundance and more pure from the bittern left after the extraction of salt from sea water. It has likewise been found efflorescing on brick walls, both old and recently erected, and in small quantity in the ashes of coals. The capillary salt of Idria, found in silvery crystals mixed with the aluminous schist in the mines of that place, and hitherto considered as a feathery alum, has been ascertained by Klaproth to consist of sulphate of magnesia, mixed with a small portion of sulphate of iron. When pure, it crystallizes in small quadrangular prisms, terminated by quadrangular pyramids or diëdral summits. Its taste is cool and bitter. It is very soluble, requiring only an equal weight of cold water, and three-fourths its weight of hot. It effloresces in the air, though but slowly. If it attract moisture, it contains muriate of magnesia or of lime. Exposed to heat, it dissolves in its own water of crystallization, and dries, but is not decomposed, nor fused, but with extreme difficulty. It consists, according to Bergman, of 33 acid, 19 magnesia, 48 water. A very pure sulphate is said to be prepared in the neighbourhood of Genoa by roasting a pyrites found there; exposing it to the air in a covered place for six months, watering it occasionally, and then lixiviating. Sulphate of magnesia is one of our most valuable purgatives; for which purpose only it is used, and for furnishing the carbonate of magnesia. Sulphate of ammonia crystallizes in slender, flattened, hexaëdral prisms, terminated by hexagonal pyramids; it attracts a little moisture from very damp air, particularly if the acid be in excess; it dissolves in two parts of cold and one of boiling water. It is not used, though Glauber, who called it his secret ammoniacal salt, vaunted its excellence in assaying. If sulphate of ammonia and sulphate of magnesia be added together in solution, they combine into a triple salt of an octaëdral figure, but varying much; less soluble than either of its component parts, unalterable in the air, undergoing on the fire the watery fusion; after which it is decomposed, part of the ammonia flying off, and the remainder subliming with an excess of acid. It contains, according to Fourcroy, 68 sulphate of magnesia, and 32 sulphate of ammonia. Sulphate of glucina crystallizes with difficulty, its solution readily acquiring and retaining a syrupy consistence; its taste is sweet and slightly astringent; it is not alterable in the air; a strong heat expels its acid, and leaves the earth pure; heated with charcoal it forms a sulphuret; infusion of galls forms a yellowish white precipitate with its solution. Yttria is readily dissolved by sulphuric acid; and as the solution goes on, the sulphate crystallizes in small brilliant grains, which have a sweetish taste, but less so than sulphate of glucina, and are of a light amethyst red colour. They

require 30 parts of cold water to dissolve them, and give up their acid when exposed to a high temperature. They are decomposed by oxalic acid, prussiate of potass, infusion of galls, and phosphate of soda. Sulphate of alumina, in its pure state, is but recently known, and it was first attentively examined by Vauquelin. It may be made by dissolving pure alumina in pure sulphuric acid, heating them for some time, evaporating the solution to dryness, drying the residuum with a pretty strong heat, redissolving it, and crystallizing. Its crystals are soft, foliaceous, shining, and pearly; but these are not easily obtained without cautious evaporation and refrigeration. They have an astringent taste, are little alterable in the air, are pretty soluble, particularly in hot water, give out their acid on exposure to a high temperature, are decomposable by combustible substances, though not readily; and do not form a phosphorus like alum. If the evaporation and desiccation directed above be omitted, the alumina will remain supersaturated with acid, as may be known by its taste, and by its reddening vegetable blue. This is still more difficult to crystallize than the neutral salt, and frequently thickens into a gelatinous mass. A compound of acidulous sulphate of alumina with potash or ammonia has long been known by the name of Alum. (See *Alumina.*) If this acidulous sulphate of lime be dissolved in water, and boiled with pure alumina, the alumina will become saturated with its base, and fall down an insipid white powder. This salt is completely insoluble, and is not deprived of its acid by heat but at a very high temperature. It may be decomposed by long boiling with the alkaline or earthy bases; and several acids convert it into common alum, but slowly. Sulphate of zircon may be prepared by adding sulphuric acid to the earth recently precipitated, and not yet dry. It is sometimes in small needles, but commonly pulverulent, very friable, insipid, insoluble in water, unless it contain some acid, and easily decomposed by heat.

SULPHUROUS ACID. It has already been observed, that sulphur burned at a low temperature absorbs less oxygen than it does when exposed to greater heat, and is consequently acidified in a slighter degree, so as to form sulphurous acid. This, in the ordinary state of the atmosphere, is a gas; but on reducing its temperature very low, by artificial cold, and exposing it to strong compression, it becomes a liquid. To obtain it in the liquid state, however, for practical purposes, it is received into water, by which it is absorbed. As the acid obtained by burning sulphur in this way is commonly mixed with more or less sulphuric acid, when sulphurous acid is wanted, it is commonly made by abstracting part of the oxygen from sulphuric acid, by means of some combustible substance. Mercury or tin is usually preferred. For the purposes of manufactures, however, chopped straw or saw-dust may be employed. If one part of mercury, and two of concentrated sulphuric acid be put into a glass retort with a long neck, and heat applied till an effervescence is produced, the sulphurous acid will arise in the form of gas, and may be collected over quicksilver or received into water, which at the temperature of 61 deg. will absorb 33 times its bulk, or nearly an eleventh of its weight. Water thus saturated is intensely acid to the taste, and has the smell of sulphur burning slowly. It destroys most vegetable colours, but the blues are reddened by it previous to their being discharged. A pleasing instance of its effect on colours may be exhibited by holding a red rose over the blue flame of a common match, by which the colour will be discharged wherever the sulphurous acid comes into contact with it, so as to render it beautifully variegated, or entirely white. If it be then dipped into water, the redness, after a time, will be restored. Sulphurous acid is used in bleaching, particularly for silks. It likewise discharges vegetable stains, and iron-moulds from linen. In combination with the salifiable bases it forms sulphites, which differ from the sulphates in their properties. The alkaline sulphites are more soluble than the sulphates, the earthy less. They are converted into sulphates by an addition of oxygen, which they acquire even by exposure to the air. The sulphite of lime is the slowest to undergo this change. A strong heat

either expels their acid entirely, or converts them into sulphates. They have all a sharp, disagreeable, sulphurous taste. The best mode of obtaining them is by receiving the sulphurous acid gas into water, holding the base or its carbonate in solution, or diffused in it in fine powder. None of them has yet been applied to any use. The sulphurous acid, according to sir H. Davy, is of a specific gravity of 2·2295. Hydrogen and carbon readily decompose it.

HYDRO-SULPHUROUS ACID. This acid contains a smaller portion of oxygen than the sulphurous acid. The mode of obtaining is described in the Edinburgh Philosophical Journal of 1819. This acid and its salts have not been applied to any useful purpose.

HYDRO-SULPHURIC ACID, contains a quantity of oxygen, intermediate between the sulphurous and sulphuric acids. It was obtained by passing sulphurous acid gas over the black oxide of manganese.

SUMACH. Common sumach (rhus coriaria) is a shrub that grows naturally in Syria, Palestine, Spain, and Portugal. In the two last it is cultivated with great care. Its shoots are cut down every year quite to the root, and after being dried they are reduced to powder by a mill, and thus prepared for the purposes of dyeing and tanning. The sumach cultivated in the neighbourhood of Montpellier is called redoul, or roudou. Mr. Hatchett found that an ounce contains about 78 or 79 grains of tannin. Sumach acts on a solution of silver just as galls do, it reduces the silver to its metallic state, and the reduction is favoured by the action of light. Of all astringents, sumach bears the greatest resemblance to galls. The precipitate, however, produced in solutions of iron by an infusion of it, is less in quantity than what is obtained by an equal weight of galls; so that in most cases it may be substituted for galls, the price of which is considerable, provided we proportionally increase its quantity. Sumach alone gives a fawn colour, inclining to green; but cotton stuffs which have been impregnated with printer's mordant, that is acetate of alumina, take a pretty good and very durable yellow. An inconvenience is experienced in employing sumach in this way, which arises from the fixed nature of its colour; the ground of the stuff does not lose its colour by exposure on the grass, so that it becomes necessary to impregnate all the stuff with different mordants, to vary the colours, without leaving any part of it white.

SUPERSALT. A compound of an acid and base, in which the acid is in excess.—See *Subsalt*.

SUPERSALTS. Salts with excess of acid.

SURFACE, (EARTH'S). The rocks and mountains composing the solid parts of the earth's surface have been divided into different classes by geologists; and the divisions are not altogether arbitrary. Certain mineral productions, as metallic ores and coral, are confined to certain rocks, in some of which they frequently occur, in others they are never found. There are also distinct characters peculiar to each class. The general divisions include,

1. Primary rocks.
2. Intermediate or transition rocks.
3. Secondary rocks.
4. Alluvial ground, and
5. Volcanic products.

Primary rocks have been so called, because no organic remains have been found in them; hence it is supposed they were formed prior to the creation of animals or vegetables. They are extremely hard, and the substances of which they are composed are crystallized. They form the lowest part of the earth's surface with which we are acquainted; and they do not only constitute the foundation on which the other rocks rest, but in many situations they pierce through the incumbent rocks and strata, and form also the highest mountains in alpine districts. We are not to conclude, when we see a mountain, or range of mountains, bounded by a plain, that they terminate at their apparent bases. On the contrary, they dip under the surface at angles more or less inclined, stretching below the lower grounds and lesser hills, and often rise again in remote districts. We may with apparent probability infer, that their formation was prior to the existence of animals or vegetables on our planet in its present state, because the inter-

mediate rocks which cover them contain the organic remains of zoophytes, or those animals which are considered as forming the first link in the chain of animated beings. The intermediate rocks have been called transition rocks, from the supposition that they were formed when the world was passing from a chaotic to a habitable state. These rocks are less perfectly crystallized than the former division, and contain, like the secondary, mechanical depositions. They separate the primary from the secondary rocks, and partake of the nature of both. The primary and transition rocks contain few saline or inflammable fossils; but they are the repositories of metallic ores, which are not often found in the third division, or what are called the secondary stratified rocks, in many of which numerous remains of vegetables and animals occur. This division contains sand-stone, coal, stratified limestone, chalk, &c. Pebbles and water-worn fragments of rocks belonging to the former divisions, are commonly found in many of the secondary rocks, hence it is inferred that they have been formed at a later period, and hence this class receives its name. Alluvial ground is the land formed from the ruins of other rocks by the agency of water; it consists of gravel, clay, &c. The substances which constitute soils are certain compounds of the earths, silica, lime, alumina, magnesia, and of the oxides of iron and manganesum, animal and vegetable matters in a decomposing state, and saline, acid, or alkaline combinations. To form a just idea of soils, it is necessary to conceive different rocks decomposed, or ground into parts or powder of different degrees of fineness; some of their soluble parts dissolved by water, and that water adhering to the mass, and the whole mixed with larger or smaller quantities of the remains of vegetables and animals, in different stages of decay. Soils appear to have been originally produced in consequence of the decomposition of rocks and strata. It often happens that soils are found in an unaltered state upon the rock from which they were derived. It is easy to form an idea of the manner in which rocks are converted into soils, by referring to the instance of soft granite, or porcelain granite. This substance consists of three ingredients, quartz, feldspar, and mica. The quartz is almost pure silicious earth, in a crystalline form. The feldspar and mica are very compounded substances; both contain silica, alumina, and oxide of iron; in the feldspar there is usually lime and potassa, in the mica, lime and magnesia. When a granite rock has been long exposed to the influence of air and water, the lime and the potassa contained in its constituent parts are acted upon by water or carbonic acid; and the oxide of iron, which is almost always in its least oxided state, tends to combine with more oxygen; the consequence is, that the feldspar decomposes, and likewise the mica, but the first the most rapidly. The feldspar, which is, as it were, the cement of the stone, forms a fine clay: the mica, partially decomposed, mixes with it as sand, and the undecomposed quartz appears as gravel, or sand of different degrees of fineness. As soon as the smallest layer of earth is formed on the surface of a rock, the seeds of lichens, mosses, and other imperfect vegetables, which are constantly floating in the atmosphere, and which have made it their resting-place, begin to vegetate; their death, decomposition, and decay, afford a certain quantity of organizable matter, which mixes with the earthy materials of the rock; in this improved soil more perfect plants are capable of subsisting; these in their turn absorb nourishment from water and the atmosphere; and after perishing afford new materials to those already provided; the decomposition of the rock still continues, and at length, by such slow and gradual processes a soil is formed in which even forest trees can fix their roots, and which is fitted to reward the labours of the cultivator. Poor and hungry soils, such as are produced from the decomposition of granite and sandstone rocks, remain very often for ages with only a thin covering of vegetation. Soils from the decomposition of limestone, chalk, and basalts, are often clothed by nature with the perennial grasses, and afford, when ploughed up, a rich bed of vegetation for every species of cultivated plant. The primary rocks are composed of pure

crystalline matter, and contain no fragments of other rocks. The secondary rocks, or strata, consist only partly of crystalline matter, contain fragments of other rocks or strata, often abound in the remains of vegetables and marine animals, and sometimes contain the remains of land animals. The primary rocks are generally arranged in large masses, or in layers vertical, or more or less inclined to the horizon. The secondary rocks are usually disposed in strata, or layers, parallel or nearly parallel to the horizon. The number of primary rocks which are commonly observed in nature are eight:—

1. Granite, which, as has been mentioned, is composed of quartz, feldspar, and mica; when these bodies are arranged in regular layers in the rock, it is called gneiss.

2. Micaceous schistus, which is composed of quartz and mica, arranged in layers, which are usually curvilineal.

3. Sienite, which consists of the substance called hornblende and feldspar.

4. Serpentine, which is constituted by feldspar, and a body named resplendent hornblende; and their separate crystals are often so small as to give the stone a uniform appearance; this rock abounds in veins of a substance called steatite, or soap rock.

5. Porphyry, which consists of crystals of feldspar, imbedded in the same material, but usually of a different colour.

6. Granular marble, which consists entirely of crystals of carbonate of lime, and which, when its colour is white and texture fine, is the substance used by statuaries.

7. Chlorite schist, which consists of chlorite, a green or grey substance, somewhat analogous to mica and feldspar.

8. Quartzose rock, which is composed of quartz in a granular form, sometimes united to small quantities of the crystalline elements, which have been mentioned as belonging to the other rocks.

The secondary rocks are more numerous than the primary; but twelve varieties include all that are usually found in the British islands.

1. Grauwacke, which consists of fragments of quartz, or chlorite schist, imbedded in a cement principally composed of feldspar.

2. Silicious sandstone, which is composed of fine quartz or sand, united by a silicious cement.

3. Limestone, consisting of carbonate of lime, more compact in its texture than in the granular marble, and often abounding in marine exuvia.

4. Aluminous schist, or shale, consisting of the decomposed materials of different rocks, cemented by a small quantity of ferruginous or silicious matter; and often containing the impressions of vegetables.

5. Calcareous sandstone, which is calcareous sand cemented by calcareous matter.

6. Ironstone, formed of nearly the same materials as aluminous schist, or shale, but containing a much larger quantity of oxide of iron.

7. Basalt, or whinstone, which consists of feldspar and hornblende, with materials derived from the decomposition of the primary rocks; the crystals are generally so small as to give the rock a homogeneous appearance, and it is often disposed in very regular columns, having usually five or six sides.

8. Bituminous or common coal, so well known as not to require description.

9. Gypsum, the substance so well known by that name, which consists of sulphate of lime, and often contains sand.

10. Rock salt, also well known.

11. Chalk, which usually abounds in remains of marine animals, and contains horizontal layers of flints.

12. Plum-pudding stone, consisting of pebbles, cemented by a ferruginous or silicious cement.

Primary and secondary rocks occur in a certain determinate order, and encircle the globe in different layers, like the coats of an onion. All the principal primary and secondary rocks are formed universally over the nucleus of the earth, in a regular series, which is the same in every part of the world. The highest mountains in these islands, and indeed in the whole of the old continent, are constituted of granite; and this rock has likewise been found at the greatest depths to which the industry of man has as yet been able to penetrate. Mica-

ceous schist is often found immediately upon granite; serpentine or marble upon micaceous schist; but the order in which the primary rocks are grouped together is various. Marble and serpentine are usually found uppermost, but granite, though it seems to form the foundation of the rocky strata of the globe, is yet sometimes discovered above micaceous schist. The secondary rocks are always incumbent on the primary; the lowest of them is usually grauwacke; upon this, limestone or sandstone is often found; coal generally occurs between sandstone or schale; basalt often exists above sandstone and limestone; rock salt almost always occurs associated with red sandstone and gypsum. Coal, basalt, sandstone, and limestone, are often arranged in different alternate layers, of no considerable thickness, so as to form a great extent of country. In a depth of less than five hundred yards, eighty of these different alternate strata have been counted. Three-fifths of the surface of the globe are covered by the sea, the average depth of which has been estimated at from five to ten miles; but great changes have taken place in the relative positions of the present continents with the ocean, which, in former ages, rolled its waves over the summits of our highest mountains. Of this, demonstrative proofs exist in our own island, and in various parts of the world. The calcareous, or limestone, mountains in Derbyshire, and Craven, in Yorkshire, rise up to the height of about two thousand feet above the present level of the sea. They contain, through their whole extent, fossil remains of zoophytes, shell-fish, and marine animals; but more abundantly in some parts than in others. The mountains of the Pyrenees are covered in the highest part at Mont Perdu with calcareous rocks, containing impressions of marine animals; and even where the impressions are not visible in the limestone it yields a fœtid cadaverous odour when dissolved in acids, owing, in all probability, to the animal matter it contains. Mont Perdu rises 10,500 feet above the level of the sea; it is the highest situation in which any marine remains have been found in Europe. In the Andes they have been observed by Humboldt at the height of 14,000 feet. In England, the calcareous mountains contain no remains of vegetables; but, in the thick beds of shale and gritstone lying upon them, are found various vegetable impressions, and above these regular beds of coal, with strata containing shells of fresh-water muscles. In the earthy limestone of the upper strata are sometimes found fossil flat-fish, with the impressions of the scales and bones quite distinct; and lastly, in and under the thick beds of clay-covering chalk, in the southern countries, the bones of the rhinoceros, the elephant, and the mammoth, are not uncommonly discovered. The sagacious naturalist Cuvier, has examined these bones from different parts of the world with much attention, and has observed characteristic variations of structure, which prove that they belong to animals not now existing on our globe: nor have many of the various zoophytes and shell-fish found in calcareous rocks, been discovered in our present seas. The fossil remains of animals not now in existence, entombed and preserved in solid rocks, present us with durable monuments of the great changes which our planet has undergone in former ages. We are led to a period when the waters of the ocean have covered the summits of our highest mountains, and are irresistibly compelled to admit one of two conclusions, either that the sea has retired and sunk down below its former level, or some power operating from beneath has lifted up the islands and continents, with all their hills and mountains, from the watery abyss to their present elevation above its surface. The following arrangement of rocks and mineral substances is as simple, intelligible, and conformable to nature, as any which has been introduced into this science.

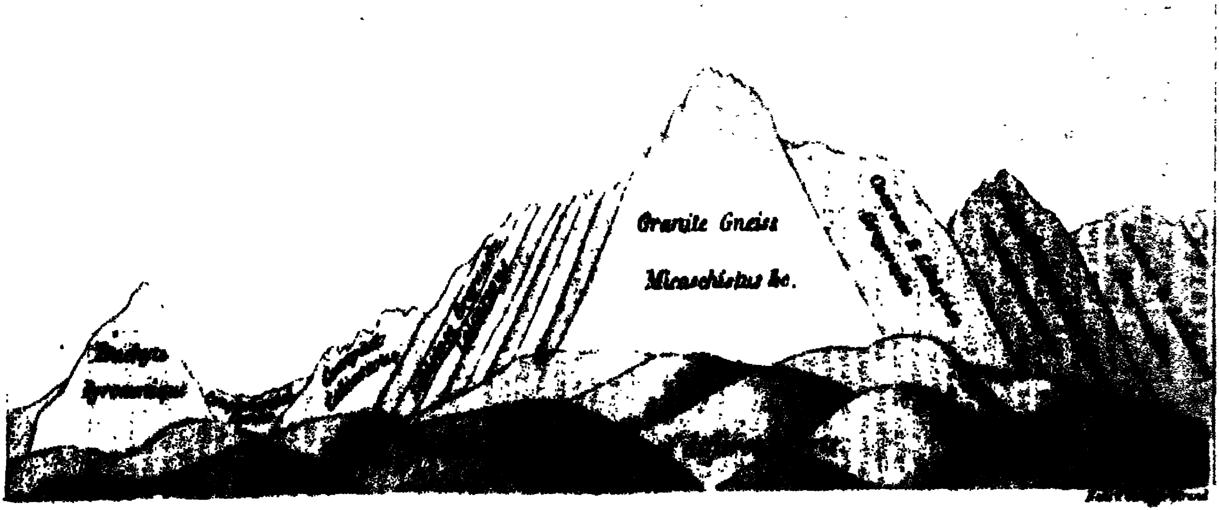
CLASS I.

Principal primary rocks.—1. Granite. 2. Gneiss, or slaty granite. 3. Micaceous schist, or mica-slate.

Subordinate rocks, which occur imbedded in the above.—1. Crystalline limestone, or statuary marble. 2. Serpentine. 3. Hornblende rock.

CLASS II.

Principal transition rocks.—1. Slate. 2. Flinty slate, sometimes porphyritic. 3. Greywacke. 4. Sub-



The Environs of Neusohl in Hungary.

London, Published by Sir R. Phillips & Co.

crystalline limestone, or common marble.

Subordinate.

1. Gypsum. 2. Imbedded trap.

CLASS III.

Superincumbent rocks of basaltic conformation, or basaltic rocks.—1. Trap, or basalt. 2. Porphyry. 3. Sienite.

CLASS IV.

Secondary stratified rocks.—1. Silicious sandstone. 2. Argillaceous sandstone. 3. Calcareous sandstone and earthy limestone. 4. Chalk.

Subordinate beds or strata, in secondary rocks—1. Trap. 2. Gypsum. 3. Rock-salt. 4. Iron-stone. 5. Coal.

CLASS V.

Alluvial.—1. Clay. 2. Sand. 3. Gravel. 4. Calcareous tufa. In this class occur beds of peat and wood-coal.

CLASS VI.

Volcanic rocks. 1. Lava. 2. Pumice. 3. Obsidian. 4. Tufa and volcanic breccias.

When, says count Chaptal, we contemplate the globe in populous districts, our attention is chiefly directed to the agency of man, and those changes of social life which produce, modify, and change the prospect around us. But when we enter the wild and romantic scene of a mountainous country, we are every where struck with the vestiges of operations carried on by the powers of nature, through a long series of ages, and upon a scale prodigiously greater than any to which the works of man can be extended. We meditate on the surrounding scene with an emotion resembling that produced by the view of a pile of ruins of a race gone to decay. We endeavour to investigate what may have been the original state of the globe; and, for want of information, our conclusions are for the most part little better founded than those of an amusing reverie. It appears from a great variety of observations, that the internal part of the globe consists of stone called granite. It is this which shows itself as the limit of all the excavations made on the surface of our planet, either by natural causes or the art of man. Water, collected in the cavity of the ocean, is carried by the winds to the tops of the most elevated mountains, where it is precipitated in rain, and forms torrents, which return with various degrees of rapidity into the common reservoir. Such an uninterrupted motion and fall must gradually attenuate and wear away the hardest rocks, and carry their pulverulent parts to distances more or less considerable. The action of the air, and the varying temperatures of the atmosphere, facilitate the attenuation, and the destruction of these rocks. Heat dries their surface, and renders it more accessible and more penetrable to the water which succeeds; cold divides them by freezing the water which has entered into their texture: the air itself affords the carbonic acid, which attacks the limestone, and causes it to effloresce; the oxygen air unites to the iron, and oxides it, insomuch that this concurrence of causes favours the disunion of principles, and consequently the action of water, which clears the surface, carries away the products of decomposition, and makes preparation for a succeeding process of the same nature. The first effect of the rain is therefore to depress the mountains. But the stones which compose them must resist in proportion to their hardness; and we ought not to be surprised, when we observe peaks that have braved the destructive action of time, and still remain to attest the primitive level of the mountains which have disappeared. The primitive rocks, alike inaccessible to the injury of ages as to the animated beings which cover less elevated mountains with their remains, may be considered as the source or origin of rivers or streams. The water which falls on their summits, flows down in torrents by their lateral surfaces. In its course it wears away the soil upon which it incessantly acts. It hollows out a bed of a depth proportioned to the rapidity of its course, the quantity of its waters, and the hardness of the rock over which it flows; at the same time that it carries along with it portions and fragments of such stones as it loosens in its course. These stones, rolled along by the water, must strike together, and break off their projecting angles, a process that must quickly have afforded those rounded flints, which form the pebbles of ri-

vers, and which are found to diminish in size, in proportion to the distance from the mountain which affords them. The pulverulent remains of mountains, or the powder which results from the rounding of these flints, are carried along with greater facility than the flints themselves: they float for a long time in the water, the transparency of which they impair: and when these said waters are less agitated, and their course becomes slackened, they are deposited in a fine and light paste, forming beds more or less thick, and of the same nature as that of the rocks to which they owe their origin. These strata gradually become drier by the agglutination of their principles; they become consistent, acquire hardness, and form silicious clay, silex, petro-silex, and all the numerous class of pebbles, which are found dispersed in strata, or in banks in the ancient beds of rivers. The mud is much more frequently deposited in the interstices left between the rounded flints themselves, which intervals it fills, and there forms a true cement, that becomes hard, and constitutes the compound stones known by the name of pudding-stones and grit-stones: for these two kinds of stone do not appear to me to differ but in the coarseness of the grain which forms them, and the cement which connects them together. We sometimes observe the granite spontaneously decomposed. The texture of the stones which form it has been destroyed; the principles or component parts are disunited and separated, and they are gradually carried away by the waters. Most silicious stones formed by the deposition of running waters, and hardened by the lapse of time, are easily subjected to a second decomposition. Iron is the principal agent of these secondary alterations; and its oxidation, determined by air or water, produces a disunion of principles. Nature may be observed in this process, by an attentive examination of such alterations as gun-flints, variolites, porphyries, jaspers, and the like, are subjected to. The decomposition of flints, chalcedonies, agates, and generally all stones of this kind, which possess a certain degree of transparency, are referable to the volatilization of the water, which forms one of their principles, and is the cause of their transparency. These stones may be considered as commencements of crystallization; and when the water is dissipated, they effervesce after the manner of certain neutral salts. Hence it arises, that the decomposition is announced by opacity, a white colour, loss of consistence and hardness; and terminates by forming a very attenuated powder, sometimes of extreme whiteness. It is this decomposition more particularly which forms clays. There are flints, the alterations of which, form effervescent marles. These do not appear to be of the nature of primitive rocks: they have the same origin as the calcareous stone, from which they differ only in consequence of a very considerable proportion of clay. The stones which we so abundantly find of this nature around us, among calcareous decompositions, may be considered as of this kind. Water filtrating through mountains of primitive rock frequently carries along with it very minutely divided particles of quartz; and proceeds to form, by deposition, stalactites, agates, rock crystal, &c. These quartzose stalactites, differently coloured, are of a formation considerably analogous to that of calcareous alabaster; and we perceive no other difference between them than that of their constituent parts. Thus far we have exhibited, in a few words the principal changes, and various modifications, to which the primitive rocks have been subjected. We have not observed either germination or life: and the metals, sulphur, and bitumens, have not hitherto presented themselves to our observation. Their formation appears to be posterior to the existence of this primitive globe; and the alterations and decompositions, which now remain to be inquired into, appear to be produced by the class of living or organized beings. On the one hand we behold the numerous class of shell animals, which cause the stony mass of our globe to increase by their remains. The spoils of these creatures, long agitated and driven about by the waves, and more or less altered by collision, form those strata and banks of limestone, in which we very often perceive impressions of those shells to which they owe their origin. On the other hand

we observe a numerous quantity of vegetables, that grow and perish in the sea; and these plants likewise deposited and heaped together by the currents, form strata, which are decomposed, lose their organization, and leave all the principles of the vegetable confounded with the earthy principle. It is to this source that the origin of pit-coal, and secondary schistus, is usually attributed; and this theory is established on the existence of the texture of decomposed vegetables very usually seen in schisti and coal, and likewise on the presence of shells and fish in most of these products. The formation of pyrites ought to be attributed to the decomposition of vegetables: it exists in greater or less abundance in all schisti and coal. A wooden shovel was found buried in the depositions of a river, converted into jet and pyrites. The decomposition of animal substances may be added to this cause, and it appears to be a confirmation of these ideas, that we find many shells passed to the state of pyrites. Not only the marine vegetables form considerable strata by their decomposition; but the remains of those that grow on the surface of the globe ought to be considered among the causes or agents, which concur in producing changes upon that surface. The calcareous mountains are constantly placed upon the surface of the primitive mountains; and though a few solitary observations present a contrary order, we ought to consider this inversion and derangement as produced by shocks, which have changed the primitive deposition. It must be observed also, that the disorder is sometimes merely apparent; and that some naturalists of little information have described calcareous mountains as inclining beneath the granite, because this last pierces, as it were, through the envelope, rises to a greater height, and leaves at its feet, almost beneath it, the calcareous remains deposited at its base. Sometimes even the limestone fills to a very great depth the crevices or clefts formed in the granite. It likewise happens frequently enough, that such waters as are loaded with the remains of the primitive granite heap them together and form secondary granites, which may exist above the calcareous stone. The calcareous mountains are decomposed by the combined action of air and water; and this fluid, which does not possess the property of holding it in solution, soon deposits in the form of gurhs, alabasters, stalactites, &c. Spars owe their formation to no other cause. Their crystallization is posterior to the origin of calcareous mountains. Waters wear down and carry away calcareous mountains with greater ease than the primitive mountains: their remains being very light are rolled along, and more or less worn. The fragments of these rocks are sometimes connected by a gluten or cement of the same nature; from which process calcareous grit and breccias arise. These calcareous remains formerly deposited themselves upon the quartzose sand; and the union of primitive matter and secondary products gives rise to a rock of a mixed nature, which is common in many places. The mountains of secondary schistus frequently exhibit to us a pure mixture of earthy principles, without the smallest vestige of bitumen. These rocks afford, by analysis, silex, alumine, magnesia, carbonate of lime, and iron; principles which are more or less united, and consequently accessible in various degrees, to the action of such agents as destroy the rocks hitherto treated of. These same principles, when disunited, and carried away by waters, give rise to a great part of the stones comprised in the magnesian genus. The same elements, worn down by the waters, and deposited under circumstances proper to facilitate crystallization, form the schorls, tourmaline, garnets, &c. It frequently happens, that the secondary schisti are interspersed with pyrites; and in this case, the simple contact of air and water facilitates their decomposition. Sulphuric acid is thus formed which combines with the various constituent principles of the stone; whence result the sulphates of iron, of magnesia, of alumine, confounded together. The pyritous schisti are frequently impregnated with bitumen, and the proportions constitute the various qualities of pit-coal.

It appears to Count Chaptal, that we may lay it down as an incontestible principle, that the pyrites is

abundant in proportion as the bituminous principle is more scarce. Hence it arises, that coals of a bad quality are the most sulphureous, and destroy metallic vessels by converting them into pyrites. The focus of volcanoes appears to be formed by a schistus of this nature; and in the analysis of the stony matters which are ejected, we find the same principles as those which constitute the schistus. We ought not therefore to be much surprised at finding schorls among volcanic products; and still less at observing, that subterranean fires throw sulphuric salts, sulphur, and other analogous products, out of the entrails of the earth.—The remains of terrestrial vegetables exhibit a mixture of primitive earths more or less covered by iron; we may therefore consider these as a matrix, in which the seeds of all stony combinations are dispersed. The earthy principles assort themselves according to the laws of their affinities; and form crystals of spar, of plaster, and even the rock crystals, according to all appearance; for we find ochreous earths in which these crystals are abundantly dispersed; we see them formed almost under our eyes. We may frequently observe indurated ochres full of these crystals, terminating in two pyramids.—The calcareous earths appear to deserve the greatest attention of naturalists. They constitute one of the most fertile means of action that nature employs; and it is even in earths nearly similar to these, that she elaborates the diamond, in the kingdoms of Golconda and Visapour.—The spoils of animals, which live on the surface of the globe, are entitled to some consideration among the number of causes, which we assign to explain the various changes our planet is subject to. We find bones in a state of considerable preservation in certain places; we can even frequently enough distinguish the species of the animals to which they have belonged. From indications of this sort it is that some writers have endeavoured to explain the disappearance of certain species; and thence to draw the conclusion, either that our planet is perceptibly cooled, or that a sensible change has taken place in the position of the axis of the earth.

General Conclusions.—That the lowest and most level parts of the earth consist of horizontal strata, composed of various substances, many of them containing marine productions. That similar strata are found in hills to a great height. That shells are sometimes so numerous as to constitute entire strata. That shells are found in elevations far above the level of the sea, and at heights to which the sea could not be raised by any existing cause. That these shells once lived in the sea, and were deposited by it. That shells continue to be found as we rise to the foot of great chains of mountains. That at this elevation, the strata, instead of being horizontal, as in plains, are of various degrees of inclination, and sometimes vertical. That from these, and other circumstances, it is inferred that there have been frequent irruptions and retreats of the sea. That as we approach the summits of lofty mountains, the remains of marine animals and shells become rare, and even wholly disappear. That their strata are wholly different, and contain no vestige of a living creature. That these strata are, by some, considered not to be precisely in the place in which they were formed. That nevertheless, as they contain no vestige of animal remains, they are considered to be the oldest rocks, and therefore are called primitive. That rocks, which, because they include no vestige of animal remains, are termed primitive, are of various kinds. That rocks, enclosing animal remains, are never found underneath, or supporting, those rocks which are termed primitive. That some primitive rocks alternate with each other, but that granite is found beneath all others, and frequently overtops all the rest. That rocks which include organic remains must have been formed after the shells they contain; and therefore, not being considered primitive, are by some termed secondary rocks; whence the terms used by geologists, of primary and secondary formations. That there are many varieties of secondary rocks, each of which has received a geological appellation. That there exists another class of substances not appropriately termed rocks, but which being considered to be the debris or ruin of rocks, by their long exposure

to the action of air and water, or both, are therefore termed alluvial deposites. That the catastrophes to which the surface of the globe has been subject have been numerous; and some of these have not been owing to irruptions of the sea, but to the agency of fresh water; and these irruptions of fresh and of salt water have been alternate. That certain deposites are always found beneath, never above, certain other deposites. That rocks which contain no animal remains are always found beneath, never resting upon, those rocks which do contain animal remains; and that those deposites which are termed alluvial, as gravel, sand, clay, &c., are never found beneath other rocks, but always resting upon them.

SWEAT. When the temperature of the body is much increased either by being exposed to a hot atmosphere, or by violent exercise, the perspired vapour not only increases in quantity, but even appears in a liquid form. This is known by the name of sweat. Besides water, it cannot be doubted that carbon is also emitted from the skin, but in what state, the experiments hitherto made do not enable us to decide. Mr. Cruickshanks found, that the air of the glass vessel in which his hand and foot had been confined for an hour, contained carbonic acid gas; for a candle burned dimly in it, and it rendered lime-water turbid. And Mr. Jurine found, that air which had remained for some time in contact with the skin, consisted almost entirely of carbonic acid gas. The same conclusion may be drawn from the experiments of Ingenhousz and Milly. Trousset has lately observed, that air was separated copiously from a patient of his while bathing. Besides water and carbon, or carbonic acid gas, the skin emits also a particular odorous substance. That every animal has a peculiar smell is well known: the dog can discover his master, and even trace him to a distance, by the scent. A dog chained up several hours after his master had set out on a journey of some hundred miles, followed his footsteps by the smell. But it is needless to multiply instances of this fact; they are too well known to every one. Now this smell must be owing to some peculiar matter which is constantly emitted; and this matter must differ somewhat either in quantity or some other property, as we see that the dog easily distinguishes the individual by means of it. Mr. Cruickshanks has made it probable, that this matter is an oily substance; or at least, that there is an oily substance emitted by the skin. He wore repeatedly, night and day, for a month, the same under-waistcoat of fleecy hosiery during the hottest part of the summer. At the end of this time he always found an oily substance accumulated in considerable masses on the nap of the inner surface of the waistcoat, in the form of black tears. When rubbed on paper it rendered it transparent, and hardened on it like grease. It burned with a white flame, and left behind it a charry residuum. Berthollet has observed the perspiration acid, and he has concluded, that the acid which is present is the phosphoric; but this has not been proved. Fourcroy and Vauquelin have ascertained, that the scurf which collects upon the skins of horses, consists chiefly of phosphate of lime, and urea is even sometimes mixed with it. According to Thenard, however, who has lately endeavoured more particularly to ascertain this point, the acid contained in sweat is the acetous; which, he likewise observes, is the only free acid contained in urine and in milk, this acid existing in both of them when quite fresh. His account of his examination of it is as follows:—The sweat is more or less copious in different individuals; and its quantity is perceptibly in the inverse ratio of that of the urine. All other circumstances being similar, much more is produced during digestion than during repose. The maximum of its production appears to be twenty-six grains and two-thirds in a minute, the minimum nine grains, troy weight. It is much inferior, however, to the pulmonary transpiration: and there is likewise a great difference between their nature and manner of formation. The one is a product of a particular secretion, similar in some sort to that of the urine; the other, composed of a great deal of water and carbonic acid, is the product of a combustion gradually effected by the atmospheric air. The sweat, in a healthy state, very sensibly reddens litmus paper or in-

fusion. In certain diseases, and particularly in putrid fevers, it is alkaline; yet its taste is always rather saline, and more similar to that of salt, than acid. Though colourless, it stains linen. Its smell is peculiar, and insupportable when it is concentrated, which is the case in particular during distillation. But before he speaks of the trials to which he subjected it, and of which he had occasion for a great quantity, he describes the method he adopted for procuring it, which was similar to that of Mr. Cruickshanks. Human sweat, according to M. Thenard, is formed of a great deal of water, free acetous acid, muriate of soda, an atom of phosphate of lime, and oxide of iron; and an inappreciable quantity of animal matter, which approaches much nearer to gelatine than to any other substance.

SWINESTONE. A variety of compact lucullite, a sub-species of limestone.

SYLVANITE. Native tellurium.

SYLVIUS (Salt of), or FEBRIFUGE (Salt of). Muriate of potash.

SYNOVIA. Within the capsular ligament of the different joints of the body, there is contained a peculiar liquid, intended evidently to lubricate the parts, and to facilitate their motion. This liquid is known among anatomists by the name of synovia. From the analysis of M. Margueron, it appears, that synovia is composed of the following ingredients:—

11·86	fibrous matter
4·52	albumen
1·75	muriate of soda
·71	soda
·70	phosphate of lime
80·46	water
100·00	

T.

TABULAR SPAR, or TABLE SPAR, prismatic augite of Jameson. Colour, greyish white. Shining pearly. Cleavage double. Fracture splintery. Translucent. Sp. gr. 3·2 to 3·5. Its constituents are, silica 50, lime 45, water 5.

TACAMAHAC, a resin, having the aroma of musk, and soluble in alcohol.

TALC, nearly resembles mica in appearance. The plates are flexible, but not elastic: it is much softer than mica, and is infusible; its colours generally incline towards green, but it is sometimes a silver white: it has a soapy feel. The constituents of the two minerals are,

	Mica.	Talc.
Silex	50	62
Alumine	35	2
Lime	1	
Magnesia	2	27
Oxide of iron	6	3
Water and loss	6	6

but these proportions vary in different specimens. Talc is an ingredient in rouge, along with carmine and benzoin. The flesh polish is given to gypsum by rubbing them with talc. There is an indurated kind, called talc slate, which is not flexible. It occurs in primitive mountains, where it forms beds in clay, slate, and serpentine.

TALCITE, earthy talc of Werner, consists of alumina 81·75, magnesia 0·75, lime 4, potash 0·5, water 13·5.

TALLOW.—See *Fat*.

TAMARINDS. According to Vauquelin, 9752 parts of the pulp consisted of

Bitartrate of potash	300
Gum	432
Sugar	1152
Jelly	576
Citric acid	864
Tartaric acid	144
Malic acid	40
Feculent matter	2880
Water	3364

TANNIN. This, which is one of the immediate principles of vegetables, was first distinguished by Seguin from the gallic acid, with which it had been confounded under the name of the astringent principle. He gave it the name of tannin, from its use in the tanning of leather, which it effects by its characteristic property, that of forming with gelatin a tough insoluble matter. It may be obtained from vegetables by macerating them in cold water; and precipitated from this solution, which contains likewise gallic acid and ex-

tractive matter, by hyperoxygenized muriate of tin. From this precipitate, immediately diffused in a large quantity of water, the oxide of tin may be separated by sulphuretted hydrogen gas, leaving the tannin in solution. Professor Proust has since recommended another method, the precipitation of a decoction of galls by powdered carbonate of potash, washing well the greenish-grey flakes that fall down with cold water, and drying them in a stove. The precipitate grows brown in the air, becomes brittle and shining like resin, and yet remains soluble in hot water. The tannin in this state, he says, is very pure. Sir H. Davy, after making several experiments on different methods of ascertaining the quantity of tannin in astringent infusions, prefers for this purpose, the common process of precipitating the tannin by gelatin; but he remarks that the tannin of different vegetables requires different proportions of gelatin for its saturation; and that the quantity of precipitate obtained is influenced by the degree in which the solutions are concentrated. M. Chenevix observed, that coffee berries acquired, by roasting, the property of precipitating gelatin; and Mr Hatchett has made a number of experiments, which show, that an artificial tannin, or substance having its chief property, may be formed, by treating with nitric acid, matters containing charcoal. It is remarkable that this tannin when prepared from vegetable substances, as dry charcoal of wood, yields, on combustion, products analogous to those of animal matters. From his experiments it would seem that tannin is in reality carbonaceous matter combined with oxygen; and the difference in the proportion of oxygen may occasion the differences in the tannin procured from different substances, that from catechu appearing to contain most. Bouillon Lagrange asserts, that tannin by absorbing oxygen is converted into gallic acid. It is not an unfrequent practice to administer medicines containing tannin in cases of debility, and at the same time to prescribe gelatinous food as nutritious. But this is evidently improper, as the tannin, from its chemical properties, must render the gelatin indigestible. For the chief use of tannin, see the following article. In general, in this country, oak bark is used for affording tannin in the manufacture of leather; but the barks of some other trees, particularly the Spanish chestnut, have lately come into use. The following table will give a general idea of the relative value of different species of barks. It is founded on the result of experiments made by sir Humphrey Davy.*

Table of Numbers exhibiting the quantity of Tannin afforded by 480lbs. of different Barks, which express nearly their relative values.

	lb.
Of middle sized oak, cut in spring	29
— Spanish chestnut	21
— Leicester willow, large size	33
— elm	13
— common willow, large	11
— ash	16
— beech	10
— horse chestnut	9
— sycamore	11
— Lombardy poplar	15
— larch	8
— hazel	14
— blackthorn	16
— coppice oak	32
— oak cut in autumn	21
— larch, cut in autumn	8
— layers of oak bark	72

The quantity of the tanning principle in barks differs in different seasons; when the spring has been very cold the quantity is smallest. On an average, four or five pounds of good oak bark are required to form one pound of leather. The inner cortical layers in all barks contain the largest quantity of tannin. Barks contain the greatest proportion of tannin at the time the buds begin to open; the smallest quantity in winter. The extractive or colouring matters found in barks, or in substances used in tanning, influence the quality of leather. Thus, skin tanned with gall-nuts is much paler than skin tanned with oak bark, which contains a brown extractive matter. Leather made from catechu is of a reddish tint. It is probable, that in the process of tanning, the matter of skin and the tanning principle first enter into union, and that the leather, at the moment of its formation, unites to the extractive matter. In general, skins in being converted into leather,

increase in weight about one-third: and the operation is most perfect when they are tanned slowly. When skins are introduced into very strong infusions of tannin, the exterior parts immediately combine with that principle, and defend the interior parts from the action of the solution: such leather is liable to crack and to decay by the action of water. The precipitates obtained from infusions containing tannin by isinglass,* when dried, contain at a medium rate about 40 per cent. of vegetable matter. It is easy to obtain the comparative value of different substances for the use of the tanner, by comparing the quantities of precipitate afforded by infusions of given weights mixed with solutions of glue or isinglass.

TANNING. The several kinds of leather are prepared from the skins of animals macerated for a long time with lime and water, to promote the separation of the hair and wool, and of the fat and fleshy parts, in which recourse is also had to the assistance of mechanical pressure, scraping, and the like. The skin, when thus deprived of its more putrescible part, and brought considerably toward the state of mere fibre, is tanned by maceration with certain astringent substances, particularly the bark of the oak tree.—The hide consists almost wholly of gelatin, and all that is necessary is, to divest it of the hair or cuticle, and any flesh or fat adhering to it. This is commonly done, after they have been soaked in water some time, and handled or trodden to cleanse them from filth, by immersing them in milk of lime. Some, instead of lime, use an acescent infusion of barley or rye-meal, or spent tan: and others recommend water acidulated with sulphuric acid. Similar acidulous waters are afterward employed for raising or swelling the hide, when this is necessary. The skins thus prepared, are finally to undergo what is properly called the tanning. This is usually done by throwing into a pit, or cistern made in the ground, a quantity of ground oak bark, that has already been used, and on this the skins and fresh bark in alternate layers, covering the whole with half a foot of tan, and treading it well down. The tanning may be accelerated by adding a little water. As it is a long time before the hide is thoroughly tanned in this mode, at least many months, during which the bark is renewed three or four times; M. Seguin steeps the skins in a strong infusion of tan, and assists its action by heat. Chaptal observes, however, that this requires an extensive apparatus for preparing the liquor and the skins: the leather imbibes so much water, that it remains spongy a long time, and wrinkles in drying; and it is extremely difficult so to arrange the hides in a copper, as to keep them apart from each other, and free of the sides of the vessel.

The following account of M. Seguin's practice, was transmitted to England in the year 1796:—To tan a skin is to take away its putrescent quality, preserving, however, a certain degree of pliability. This is effected by incorporating with the skin particles of a substance, which destroys their tendency to putrefaction. The operations relating to tanning are therefore of two kinds; the first is merely depriving the skin of those parts which would oppose its preservation, or which adhere to it but little, such as hair and flesh; the other consists in incorporating with it a substance, which may prevent its putrefaction. The operations of the first kind are technically termed unhairing and fleshing; the operations of the second kind belong to tanning, properly so called. Fleshing is an operation merely mechanical; unhairing is a mechanical operation if performed by shaving; or a chemical operation, if effected by dissolution or decomposition of the substance which connects the hair with the skin. According to the ancient method the dissolution of this substance was effected by means of lime; the decomposition either by the vinous fermentation of barley, by the acetous fermentation of oak bark, or by the putrid fermentation, produced by piling the hides one upon another. Unhairing by means of lime would often take twelve or fifteen months; this operation with barley, or the acetous part of tan, could not be performed in less than two months. The slowness of these operations, which the experiments of Seguin have shown may be finished in a few days, and in a more advantageous manner, by means of the same substances, proves,

that the nature of those operations was not understood by those who performed them. Those of tanning, properly so called, were as little known, as the details we are about giving will prove, which we compare with the least improved routine now in practice. Whatever the method of unhairing was, the mode of tanning was always the same, for skins unhaired with lime, or those prepared with barley or tan. This mode of operating would take eighteen months or two years, often three years, when it was wished to tan the hides thoroughly. Among the substances for tanning, gall nut, sumach, and the bark of oak, to which may be added catechu, appear the most proper, at least, in the present state of our knowledge. In the middle departments of France, oak-bark is preferred, because it is the cheapest and most abundant substance. To use it, it is first ground to powder; then, according to the old mode, it is put into large holes dug in the ground, which are filled by alternate layers of ground bark and unhaired hides. As the principle which effects the tanning cannot act in the interior of the skin, unless carried in by some liquid in which it is first dissolved, tanning is not produced by the immediate action of the powdered bark upon the skin, but only by the action of the dissolution of the tanning principle originally contained in the bark. The tan therefore has the tanning property only when wetted so much as not to absorb all the water thrown on it. But as tanners put in their vats only a small portion of water compared to what would be necessary to deprive the bark of all the tanning principle which it contains, the bark put into the vats preserves, when taken out, a portion of its tanning principle. This waste is not the only disadvantage of the old modes of proceeding; they are, besides, liable never to produce in the skins a complete saturation with the tanning principle. For, as the property of attraction is common to all bodies, according to the different degrees of saturation, the water containing in solution a certain quantity of the tanning principle, will not part to a fixed weight of skins, with as much as the same quantity of water will, in which a greater quantity of the principle is dissolved. As the water, which, in the old manner of proceeding, is in the vats, can contain but a small portion of the tanning principle, owing to the nature of the operation, it can give but a small portion of it to the skin, and even this it parts with by slow degrees. Hence, the slowness in the tanning of skins according to the old method, which required two whole years, and sometimes three, before a skin was well tanned to the centre. Hence also, the imperfection of skins tanned by that method; an imperfection resulting from the non-saturation of the tanning principle, even when it had penetrated the centre. The important desideratum was, therefore, to get together, within a small compass, the tanning principle, to increase its action, and produce in the hide a complete saturation in a much shorter time than that necessary for the incomplete tanning produced in vats. But, first of all, it was necessary to analyze the skin, analyze the leather, and analyze the oak-bark. The principles of these three substances were to be insulated, and their action upon one another determined, the influence of their combination upon that action known, and the circumstances most productive of its greatest action found out. Seguin by following this method, has determined:—

1. That the skin deprived of flesh and hair is a substance, which can easily, by a proper process, be entirely converted into an animal jelly (glue).

2. That a solution of this last mentioned substance, mixed with a solution of tan, forms immediately an imputrescible and indissoluble compound.

3. That the solution of tan is composed of two very distinct substances; one of which precipitates the solution of glue, and which is the true tanning substance; the other, which precipitates sulphate of iron, without precipitating the solution of glue, and which produces only the necessary disoxygenation of the skin, and of the substance which connects the hair to the skin.

4. That the operation of tanning is not a simple combination of the skin with the principle which precipitates the glue, but a combination of that principle with the skin disoxygenized

by the substance, which in the dissolution of tan is found to precipitate the sulphate of iron; so that every substance proper for tanning should possess the properties of precipitating the solution of glue, and of precipitating the sulphate of iron.

5. That the operation of tanning consists in swelling the skins by means of an acidulous principle; to disoxygenize by means of the principle which in the solution of the bark precipitates the solution of sulphate of iron, that substance which connects the hair to the skin, and thus produce an easy unhairing; to disoxygenize the skin by means of the same principle, and to bring it by this disoxygenation to the middle state between glue and skin; and then to combine with it, after this disoxygenation, and while it is in this middle state, that particular substance in oak-bark, as well as in many other vegetables, which is found to precipitate the solution of glue, and which is not, as has been hitherto conceived, an astringent substance.

Agreeably to these discoveries, there only remains, in order to tan speedily and completely, to condense the tanning principle so as to accelerate its action. Seguin, to effect this, follows a very simple process. He *pours water upon the powdered tan,* contained in an apparatus nearly similar to that made use of in saltpetre works. This water, by going through the tan, takes from it a portion of its tanning principle, and by successive filtrations, dissolves every time an additional quantity of it, till at last the bark rather tends to deprive it of some than to give up more. Seguin succeeds in bringing these solutions to such a degree of strength that, he says, he can, by taking proper measures, tan calf-skin in 24 hours, and the strongest ox-hides in seven or eight days. These solutions containing a great quantity of the tanning principle, impart to the skin as much of it as it can absorb, so that it can then easily attain a complete saturation of the principle, and produce leather of a quality much superior to that of most countries famous for their leather. On the above we have only to remark, that every new art or considerable improvement must unavoidably be attended with many difficulties in the establishment of a manufactory in the large way. From private inquiry we find, that this also has its difficulties, which have hitherto prevented its being carried into full effect in this country. Of what nature these may be we are not decidedly informed, and mention them in this place only to prevent manufacturers from engaging in an undertaking of this kind, without cautious inquiry. M. Desmond has recommended to saturate water *with tannin, by affusion* on successive portions of oak bark, or whatever may be used; and when *the bark will give out no more tannin,* to extract what gallic acid stills remains in it, by pouring on fresh water. *To the latter, or acidulous liquor,* he adds one-thousandth part by measure of sulphuric acid; and in this steeps the hide, till the hair will come off easily by scraping. When raising is necessary, he steeps the hide ten or twelve hours in water acidulated with *a five hundredth part, by measure, of* sulphuric acid; after which they are to be washed repeatedly, and scraped *with the round knife. Lastly, the* hides are to be steeped some hours in a weak solution of tannin, then a *few days in a stronger, and this must be* renewed as the tannin is exhausted, till the leather is fully tanned. For *the softer skins, as calves, goats, &c.* he does not use the acid mixture, but milk of lime. Of substances used for tanning, sir H. Davy observes, that 1lb. of catechu is nearly equal to $2\frac{1}{2}$ of galls, 3 of sumach, $7\frac{1}{2}$ of the bark of the Leicester willow, $8\frac{1}{2}$ of oak-bark, 11 of the bark of the Spanish chestnut, 18 of elm-bark, and 21 of common willow-bark, with respect to the tannin contained in them. He observes too, that leather slowly tanned in weak infusions of barks appears to be better in quality, being both softer and stronger than when tanned by strong infusions; and he ascribes this to the extractive matter they imbibe. This principle therefore affects the quality of the material employed in tanning; and galls which contain a great deal of tannin, make a hard leather, and liable to crack, from their deficiency of extractive matter. — *Ann. de Chim.* — *Philos. Trans. Philos. Mag.* — *Chaptal's Chem.*

TANTALUM. See *Columbium.*

TARRAS, or TERRAS. A volca

nic earth used as a cement. It does not differ much in its principles from pozzolana; but it is much more compact, hard, porous, and spongy. It is generally of a whitish-yellow colour, and contains more heterogeneous particles, as spar, quartz, schorl, &c. and something more of a calcareous earth. It effervesces with acids, is magnetic, and fusible *per se*. When pulverized, it serves as a cement, like pozzolana. It is found in Germany and Sweden. See *Lime*.

TARTARIC ACID. The casks in which some kinds of wine are kept become incrusted with a hard substance, tinged with the colouring matter of the wine, and otherwise impure, which has long been known by the name of argal, or tartar, and distinguished into red and white according to its colour. This being purified by solution, filtration, and crystallization, was termed cream or crystals of tartar. It was afterwards discovered, that it consisted of a peculiar acid combined with potash; and the supposition that it was formed during the fermentation of the wine, was disproved by Boerhaave, Neumann, and others, who showed that it existed ready formed in the juice of the grape. It has likewise been found in other fruits, particularly before they are too ripe; and in the tamarind, sumac, balm, carduus benedictus, and the roots of restharrow, germander, and sage. The separation of tartaric acid from this acidulous salt, is the first discovery of Scheele that is known. He saturated the superfluous acid by adding chalk to a solution of the supertartrate in boiling water as long as any effervescence ensued, and expelled the acid from the precipitated tartrate of lime by means of the sulphuric. Or four parts of tartar may be boiled in twenty or twenty-four of water, and one part of sulphuric acid, added gradually. By continuing the boiling the sulphate of potash will fall down. When the liquor is reduced to one-half, it is to be filtered, and if any more sulphate be deposited by continuing the boiling, the filtering must be repeated. When no more is thrown down, the liquor is to be evaporated to the consistence of a syrup, and thus crystals of tartaric acid, equal to half the weight of the tartar employed, will be obtained. The tartaric acid may be procured in needly or laminated crystals, by evaporating a solution of it. Its taste is very acid and agreeable, so that it may supply the place of lemon-juice. It is very soluble in water. Burnt in an open fire it leaves a coaly residuum; in close vessels it gives out carbonic acid and carburetted hydrogen gas. By distilling nitric acid off the crystals they may be converted into oxalic acid, and the nitric acid passes to the state of nitrous. The tartrates of lime and barytes are white, pulverulent, and insoluble. Tartrate of strontian, formed by the double decomposition of muriate of strontian and tartrate of potash, according to Vauquelin, is soluble, crystallizable, and consists of 52·88 strontian and 47·12 acid. That of magnesia forms a gelatinous or gummy mass. Tartrate of potash, the tartarized kali of the London college, and vegetable salt of some, formerly called soluble tartar, because much more so than the supertartrate, crystallizes in oblong squares, bevelled at the extremities. It has a bitterish taste, and is decomposed by heat, as its solution is even by standing some time. It is used as a mild purgative. The supertartrate of potash, already mentioned at the beginning of this article, is much used as a cooling and gently opening medicine, as well as in several chemical and pharmaceutical preparations. Dissolved in water, with the addition of a little sugar, and a slice or two of lemon-peel, it forms an agreeable cooling drink by the name of imperial; and if an infusion of green balm be used instead of water, it makes one of the pleasantest liquors of the kind with which we are acquainted. Mixed with an equal weight of nitre, and projected into a red-hot crucible, it detonates, and forms the white flux; treated in the same way with half its weight of nitre, it forms the black flux; and simply mixed with nitre in various proportions, it is called raw flux. It is likewise used in dyeing, in hat-making, in gilding, and in other arts. By saturating the superfluous acid in this supertartrate with soda, a triple salt is formed, which crystallizes in large regular prisms of eight nearly equal sides, of a bitter taste, efflorescent, and soluble in about five parts of water. It con-

sists, according to Vauquelin, of 54 parts tartrate of potash and 46 tartrate of soda; and was once in much repute as a purgative, by the name of Rochelle salt, or sel de seignette. The tartrate of soda is much less soluble than this triple salt, and crystallizes in slender needles or thin plates. The tartrate of ammonia is very soluble, bitter salt, and crystallizes easily. It is spontaneously decomposable. This too forms with tartrate of potash a triple salt, the solution of which yields by cooling, fine pyramidal or prismatic efflorescent crystals. Though both the neutral salts that compose it are bitter, this is not, but has a cooling taste.

TARTAR, is deposited on the sides of casks during the fermentation of wine: it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from 10 to 15 francs the quintal. All wines do not afford the same quantity of tartar. Neumann remarked, that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity. Tartar is distinguished from its colour into red and white: the first is afforded by red wine. Tartar is purified from an abundant extractive principle, by processes which are executed at Montpellier and at Venice. The following is the process used at Montpellier:—The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of cream of tartar, or the acidulous tartrate of potash. M. Desmaretz has informed us, that the process used at Venice consists,

1. In *drying* the tartar in iron boilers.

2. Pounding it, and dissolving it in hot water, which, by cooling, affords purer crystals.

3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product. See *Tartaric Acid*.

TARTAR (CHALYBEATED). This is prepared by boiling three parts of the supertartrate of potash and two of iron filings in forty-six parts of water, till the tartar appears to be dissolved. The liquor is then filtered, and crystals are deposited on cooling, more of which are obtained by continuing the evaporation.

TARTAR (CREAM OF). The popular name of the purified supertartrate of potash.

TARTAR (CRUDE). The supertartrate of potash in its natural state, before it has been purified.

TARTAR (EMETIC). The tartrate of potash and antimony. See *Antimony*.

TARTAR OF THE TEETH. The popular name for the concretion that so frequently incrusts the teeth, and which consists apparently of phosphate of lime.

TARTAR (REGENERATED). Acetate of potash.

TARTAR (SALT OF). The subcarbonate of potash.

TARTAR (SECRET FOLIATED EARTH OF). Acetate of potash.

TARTAR (SOLUBLE). Neutral tartrate of potash.

TARTAR (VITRIOLATED). Sulphate of potash.

TARTARINE. The name given by Kirwan to the vegetable alkali, or potash.

TARTAROUS ACID. See *Tartaric Acid*.

TARTRATE. A neutral compound of the tartaric acid with a base.

TEARS. That peculiar fluid which is employed in lubricating the eye, and which is emitted in great quantities when we express grief by weeping, is known by the name of tears. For an accurate analysis of this fluid we are indebted to Messrs. Fourcroy and Vauquelin. The liquid called tears is transparent and colourless like water; it has scarcely any smell, but its taste is always perceptibly salt. Its specific gravity is somewhat greater than that of distilled water. It gives to paper stained with the juice of the petals of mallows or violets a permanently green colour, and therefore contains a fixed alkali. It unites

with water, whether cold or hot, in all proportions. Alkalis unite with it readily, and render it more fluid. The mineral acids produce no apparent change upon it. Exposed to the air, this liquid gradually evaporates, and becomes thicker. When nearly reduced to a state of dryness, a number of cubic crystals form in the midst of a kind of mucilage. These crystals possess the properties of muriate of soda; but they tinge vegetable blue greens, and therefore contain an excess of soda. The mucilaginous matter acquires a yellowish colour as it dries. Tears are composed of the following ingredients:—

1. Water.
2. Mucus.
3. Muriate of soda.
4. Soda.
5. Phosphate of lime.
6. Phosphate of soda.

The saline parts amount only to about 0·01 of the whole, or probably not so much.

TEETH. The basis of the substance that forms the teeth, like that of other bones, (See *Bone*) appears to be phosphate of lime. The enamel, however, according to Mr. Hatchett, differs from other bony substances in being destitute of cartilage: for raspings of enamel, when macerated in diluted acids, he found were wholly dissolved; while raspings of bone, treated in the same manner, always left a cartilaginous substance untouched. See *Bone*.

TELESIA. Sapphire.

TELLURIUM. Mueller first suspected the existence of a new metal in the aurum paradoxicum, or problematicum, which has the appearance of an ore of gold, though very little can be extracted from it. Klaproth afterward established its existence, not only in this but in some other Transylvanian ores, and named it tellurium. Pure tellurium is of a tin-white colour, verging to lead-grey, with a high metallic lustre; of a foliated fracture; and very brittle, so as to be easily pulverized. Its specific gravity is 6·115. It melts before ignition, requiring a little higher heat than lead, and less than antimony; and, according to Gmelin, is as volatile as arsenic. When cooled without agitation, its surface has a crystallized appearance. Before the blowpipe on charcoal it burns with a vivid blue light, greenish on the edges; and is dissipated in greyish-white vapours, of a pungent smell, which condense into a white oxide. This oxide heated on charcoal is reduced with a kind of explosion, and soon again volatilized. Heated in a glass retort it fuses into a straw-coloured striated mass. It appears to contain about 16 per cent of oxygen. Tellurium is oxidized and dissolved by the principal acids. To sulphuric acid it gives a deep purple colour. Water separates it in black flocculi, and heat throws it down in a white precipitate. With nitric acid it forms a colourless solution, which remains so when diluted, and affords slender dendritic crystals by evaporation. The muriatic acid, with a small portion of nitric, forms a transparent solution, from which water throws down a white submuriate. This may be redissolved almost wholly by repeated affusions of water. Alcohol likewise precipitates it. Sulphuric acid, diluted with two or three parts of water, to which a little nitric acid has been added, dissolves a large portion of the metal, and the solution is not decomposed by water. The alkalis throw down from its solutions a white precipitate, which is soluble in all the acids, and by an excess of the alkalis or their carbonates. They are not precipitated by prussiate of potash. Tincture of galls gives a yellow flocculent precipitate with them. Tellurium is precipitated from them in a metallic state by zinc, iron, tin, and antimony. Tellurium fused with an equal weight of sulphur, in a gentle heat, forms a lead-coloured striated sulphuret. Alkaline sulphurets precipitate it from its solutions of a brown or black colour. In this precipitate either the metal or its oxide is combined with sulphur. Each of these sulphurets burns with a pale blue flame, and white smoke. Heated in a retort, part of the sulphur is sublimed, carrying up a little of the metal with it. It does not easily amalgamate with quicksilver.

TELLURETTED HYDROGEN. A gas obtained by the union of tellurium and hydrogen.

TEMPERATURE. The sensible

heat, as measured by the thermometer.—See *Caloric, Combustion, Congelation, and Pyrometer.*

TENACITY.—See *Adhesion.*

TENNANTITE, consists of copper 45·32, sulphur 28·74, arsenic 11·84, iron 9·26, silica 5.

TERRA PONDEROSA.—See *Heavy Spar and Barytes.*

TERRA JAPONICA. Catechu.

TERRA LEMNIA. A red bolar earth formerly esteemed in medicine.

TERRA SIENNA. A brown bole or ochre, with an orange cast, brought from Sienna in Italy, and used in painting, both raw and burnt. When burnt it becomes of a darker brown. It resists the fire a long time without fusing. It adheres to the tongue very forcibly.

TERRE VERTE. This is used as a pigment, and contains iron in some unknown state, mixed with clay, and sometimes with chalk and pyrites.

THALLITE. Epidote or Pistacite.

THERMOMETER. An instrument for measuring heat, founded on the principle, that the expansions of matter are proportional to the augmentations of temperature.

THORINA. An earth discovered in 1816 by M. Berzelius, in small quantities in the gadolinite of Korarvet. It resembles zirconia. To obtain it from those minerals that contain protoxide of cerium and yttria, we must separate the oxide of iron by succinate of ammonia. The deutoxide of cerium is then precipitated by the sulphate of potash; after which the yttria and the new earth are precipitated together by caustic ammonia. Dissolve them in muriatic acid. Evaporate the solution to dryness, and pour boiling water on the residue, which will dissolve the greatest part of the yttria. Dissolve the residue in muriatic or nitric acid, and evaporate it till it becomes as exactly neutral as possible. Then pour water upon it, and boil it for an instant. The new earth is precipitated. By saturating this liquid, and boiling it a second time, we obtain a new precipitate of the new earth. This earth, when separated by the filter, has the appearance of a gelatinous semi-transparent mass. When washed and dried it becomes white, absorbs carbonic acid, and dissolves with effervescence in acids. Though calcined, it retains its white colour, and when the heat to which it has been exposed was only moderate, it dissolves readily in muriatic acid; but if the heat has been violent, it will not dissolve till it be digested in strong muriatic acid. When dissolved in sulphuric acid with a slight excess of acid, and subjected to evaporation, it yields transparent crystals. This earth dissolves very easily in nitric acid. It dissolves in muriatic acid, in the same manner as in nitric acid. The solution does not crystallize. This earth combines with avidity with carbonic acid. The ferruginous prussiate of potash poured into a solution of this earth, throws down a white precipitate, which is completely re-dissolved by muriatic acid. Caustic potash and ammonia have no action on this earth newly precipitated. The solution of carbonate of potash or carbonate of ammonia, dissolves a small quantity of it, which precipitates again when the liquid is supersaturated with an acid, and then neutralized by caustic ammonia. Thorina differs from alumina by its insolubility in hydrate of potash; from glucina by the same property; from yttria by its purely astringent taste, without any sweetness, and by the property which its solutions possess of being precipitated by boiling when they do not contain too great an excess of acid. It differs from zirconia by the following properties:—1. After being heated to redness, it is still capable of being dissolved in acids. 2. Sulphate of potash does not precipitate it from its solutions, while it precipitates zirconia from solutions containing even a considerable excess of acid. 3. It is precipitated by oxalate of ammonia, which is not the case with zirconia. 4. Sulphate of thorina crystallizes readily, while sulphate of zirconia, supposing it free from alkali, forms, when dried, a gelatinous, transparent mass, without any trace of crystallization.

THORINUM. It is supposed that the preceding earth, like lime, barytes, and others, is metallic; and in that case the base would be properly named thorinum.

THULITE. A peach-blossom-coloured mineral found in Norway.

THUMERSTONE. Axinite.

TIN, is a metal of a yellowish-white colour, considerably harder than lead, scarcely at all sonorous, very malleable, though not very tenacious. Under the hammer it is extended into leaves called tin-foil, which are about one-thousandth of an inch thick, and might easily be beaten to less than half that thickness, if the purposes of trade required it. The process for making tin-foil consists simply in hammering out a number of plates of this metal, laid together upon a smooth block or plate of iron. The smallest sheets are the thinnest. Its specific gravity is 7·29. It melts at about the 442 deg. of Fahrenheit's thermometer, and by a continuance of the heat it is slowly converted into a white powder by oxidation. Like lead, it is brittle when heated almost to fusion, and exhibits a grained or fibrous texture if broken by the blow of a hammer; it may also be granulated by agitation at the time of its transition from the fluid to the solid state. The oxide of tin resists fusion more strongly than that of any other metal; from which property it is useful to form an opaque white enamel when mixed with pure glass in fusion. The brightness of its surface, when scraped, soon goes off by exposure to the air; but it is not subject to rust or corrosion by exposure to the weather. Concentrated sulphuric acid, assisted by heat, dissolves half its weight of tin, at the same time that sulphureous gas escapes in great plenty. By the addition of water, an oxide of tin is precipitated. Sulphuric acid slightly diluted likewise acts upon this metal; but if much water be present the solution does not take place. In the sulphuric solution of tin, there is an actual formation or extrication of sulphur, which renders the fluid of a brown colour while it continues heated, but subsides by cooling. The tin is likewise precipitated in the form of a white oxide, by a continuance of the heat, or by long standing without heat. This solution affords needle-formed crystals by cooling. Nitric acid and tin combine together very rapidly, without the assistance of heat. Most of the metal falls down in the form of a white oxide, extremely difficult of reduction; and the small portion of tin which remains suspended, does not afford crystals, but falls down, for the most part, upon the application of heat to inspissate the fluid. The strong action of the nitric acid upon tin, produces a singular phenomenon, which is happily accounted for by the modern discoveries in chemistry. M. de Morveau has observed, that in a solution of tin by the nitric acid, no elastic fluid is disengaged, but ammonia is formed. This alkali must have been produced by the nitrogen of that part of the nitric acid which was employed in affording oxygen to oxidise the tin. The muriatic acid dissolves tin very readily, at the same time that it becomes of a darker colour, and ceases to emit fumes. A slight effervescence takes place with the disengagement of a fœtid inflammable gas. Muriatic acid suspends half its weight of tin, and does not let it fall by repose. It affords permanent crystals by evaporation. If the tin contain arsenic, it remains undissolved at the bottom of the fluid. Recent muriate of tin is a very delicate test of mercury. M. Chenevix says, if a single drop of saturated solution of neutralized nitrate, or muriate of mercury, be put into 500 grains of water, a few drops of solution of muriate of tin will render it a little turbid, and of a smoke-grey. He adds, that the effect is perceptible if ten times as much water be added. Aqua regia, consisting of two parts nitric and one muriatic acid, combines with tin with effervescence, and the developement of much heat. In order to obtain a permanent solution of tin in this acid, it is necessary to add the metal by small portions at a time, so that the one portion may be entirely dissolved before the next piece is added. Aqua regia in this manner dissolves half its weight of tin. The solution is of a reddish-brown, and in many instances assumes the form of a concrete gelatinous substance. The addition of water sometimes produces the concrete form in this solution, which is then of an opal colour, on account of the oxide of tin diffused through its substance. The uncertainty attending these experiments with the solution of tin in aqua regia, seems to depend upon the want of a sufficient degree of accuracy in ascertaining the specific gravities of the two acids which are mixed, the

quantities of each, and of the tin, together with that of the water added. It is probable that the spontaneous assumption of the concrete state depends upon water imbibed from the atmosphere. The solution of tin in aqua regia is used by dyers, to heighten the colours of cochineal, gum-lac, and some other red tinctures, from crimson to a bright scarlet, in the dyeing of woollens. The acetic acid scarcely acts upon tin. The operation of other acids upon this metal has been little inquired into. Phosphate, fluate, and borate of tin have been formed by precipitating the muriate with the respective neutral salts. If the crystals of the saline combination of copper with the nitric acid be grossly powdered, moistened, and rolled up in tin-foil, the salt deliquesces, nitrous fumes are emitted, the mass becomes hot, and suddenly takes fire. In this experiment the rapid transition of the nitric acid to the tin, is supposed to produce or develope heat enough to set fire to the nitric salts; but by what particular changes of capacity has not been shewn. If small pieces of phosphorus be thrown on tin in fusion, it will take up from 15 to 20 per cent. and form a silvery white phosphuret of a foliated texture, and soft enough to be cut with a knife, though but little malleable. This phosphuret may be formed likewise by fusing tin filings with concrete phosphoric acid. Tin unites with bismuth by fusion, and becomes harder and more brittle in proportion to the quantity of that metal added. With nickel it forms a white brilliant mass. It cannot easily be united in the direct way with arsenic, on account of the volatility of this metal; but by heating it with the combination of the arsenical acid and potash, the salt is partly decomposed; and the tin combining with the acid, becomes converted into a brilliant brittle compound of a plaited texture. It has been said, that al. tin contains arsenic, and that the crackling noise which is heard upon bending pieces of tin, is produced by this impurity; but from the experiment of Bayen, this appears not to be the fact. Cobalt unites with tin by fusion, and forms a grained mixture of a colour slightly inclining to violet. Zinc unites very well with tin, increasing its hardness and diminishing its ductility, in proportion as the quantity of zinc is greater. This is one of the principal additions used in making pewter, which consists for the most part of tin. The best pewter does not contain above one-twentieth part of admixture, which consists of zinc, copper, bismuth, or such other metallic substances as experience has shewn to be most conducive to the improvement of its hardness and colour. The inferior sorts of pewter, more especially those used abroad, contain much lead, have a bluish colour, and are soft. The tin usually met with in commerce in this country, has no admixture to impair its purity, except such as may accidentally elude the workmen at the mines. But the tin met with in foreign countries is so much debased by the dealers in that article, especially the Dutch, that pewter and tin are considered abroad as the same substance. Antimony forms a very brittle hard mixture with tin; the specific gravity of which is less than would have been deduced by computation from the specific gravities and quantities of each, separately taken. Tungsten fused with twice its weight of tin, affords a brown spongy mass, which is somewhat ductile. The uses of tin are very numerous, and so well known that they scarcely need be pointed out. Several of them have been already mentioned. The tinning of iron and copper, the silvering of looking-glasses, and the fabrication of a great variety of vessels and utensils for domestic and other uses, are among the advantages derived from this metal.

TINCAL. Crude borax, as imported from the East Indies.

TINGLASS. Bismuth.

TINNING.—See *Iron*.

TITANITES. This name has been given to certain ores of titanium, containing that metal in the state of oxide. See the following article

TITANIUM. Several years ago, the Rev. Mr. Gregor discovered in a kind of ferruginous sand, found in the vale of Menachan, in Cornwall, what he supposed to be the oxide of a new metal, but was unable to reduce. Klaproth, afterwards analyzing what was called the red schorl of Hungary,

found it to be the pure oxide of a new metal, which he named titanium, and the same with the menachanite of Mr. Gregor. Since that oxide of titanium has been discovered in several fossils. We do not know that titanium has been completely reduced except by Lampadius, who effected it by means of charcoal only. The oxide he employed was obtained from the decomposition of gallate of titanium by fixed alkali. The metal was of a dark copper colour, with much metallic brilliancy, brittle, and in small scales considerably elastic. It tarnishes in the air, and is easily oxidized by heat. It then acquires a bluish aspect. It detonates with nitre, and is highly infusible. All the dense acids act upon it with considerable energy. According to Vauquelin, it is volatilized by intense heat. The native red oxide is insoluble in the sulphuric, nitric, muriatic, and nitro-muriatic acids: but if it be fused with six parts of carbonate of potash, the oxide is dissolved with effervescences. The sulphuric solution when evaporated becomes gelatinous, the nitric affords rhomboidal crystals by spontaneous evaporation, but is rendered turbid by ebullition; the muriatic becomes gelatinous, or flocculent, by heat, and transparent crystals form in it when cooled; but if it be boiled, oxygenized muriatic acid gas is evolved, and a white oxide thrown down. Phosphoric and arsenic acids take it from the others, and form with it a white precipitate. These precipitates are soluble in muriatic acid, but in no other. The solutions of titanium give white precipitates with the alkalis, or their carbonates; tincture of galls gives a brownish-red, and prussiate of potash a brownish-yellow. If the prussiate produce a green precipitate, this, according to Lowitz, is owing to the presence of iron. Zinc immersed in the solutions, changes their colour from yellow to violet, and ultimately to an indigo; tin produces in them a pale red tint, which deepens to a bright purple red. Hydrosulphuret of potash throws down a brownish-red precipitate, but they are not decomposed by sulphuretted hydrogen. By exposing phosphate of titanium, mixed with charcoal and borax, to a violent heat, in a double crucible luted, M. Chenevix obtained a pale white phosphuret, with some lustre, brittle, of a granular texture, and not very fusible. The oxides of iron and titanium, exposed to heat with a little oil and charcoal, produce an alloy of a grey colour, intermixed with brilliant metallic particles of a golden yellow. Oxide of titanium was used to give a brown or yellow colour in painting on porcelain, before its nature was known; but it was found difficult to obtain from it an uniform tint, probably from its not being in a state of purity.

TOLU (Balsam of). This substance is obtained from the toluifera balsamum, a tree which grows in South America. The balsam flows from incisions made in the bark. It comes to Europe in small gourd shells. It is of a reddish-brown colour and considerable consistence; and when exposed to the air, it becomes solid and brittle. Its smell is fragrant, and continues so, even after the balsam has become thick by age. When distilled with water, it yields very little volatile oil, but impregnates the water strongly with its taste and smell. A quantity of benzoic acid sublimes, if the distillation be continued. Mr. Hatchett found it soluble in the alkalis, like the rest of the balsams. When he dissolved it in the smallest possible quantity of lixivium of potash, it completely lost its own odour, and assumed a fragrant smell, somewhat resembling that of the clove pink. "This smell," Mr. Hatchett observes, "is not fugitive, for it is still retained by a solution which was prepared in June, and has remained in an open glass during four months." When digested in sulphuric acid, a considerable quantity of pure benzoic acid sublimes. When the solution of it in this acid is evaporated to dryness, and the residuum treated with alcohol, a portion of artificial tannin is obtained; the residual charcoal amounts to 0·54 of the original balsam. Mr. Hatchett found that it dissolved in nitric acid, with nearly the same phenomena as the resins: but it assumed the smell of bitter almonds, which led him to suspect the formation of prussic acid. During the solution in nitric acid, a portion of benzoic acid sublimes. By repeated digestions, it is converted into artificial

tannin. It is totally soluble in alcohol, from which water separates the whole of it, except the benzoic acid.

TOMBAC. A white alloy of copper with arsenic, commonly brittle, though if the quantity of arsenic be small, it is both ductile and malleable in a certain degree. It is sometimes called white copper.

TOPAZ. According to Professor Jameson, this mineral contains three sub-species, common topaz, schorlite, and physalite.

Common topaz.—Colour, wine-yellow. In granular concretions, disseminated and crystallized. Splendent and vitreous. Cleavage perfect and perpendicular to the axis of the prism. Transparent. Refracts double. Harder than quartz or emerald, but softer than corundum. Sp. gr. 3·4 to 3·6. The topaz of Brazil, Siberia, Mucla in Asia-Minor, and Saxony, when heated, exhibit at one extremity positive, and at the other, negative electricity. It also becomes electrical by friction, and retains its electricity very long. Its constituents are,

	Braz. Top.	Sax. T.	Sax. T.
Alumina	58·38	57·45	59
Silica	34·01	34·24	35
Fluoric acid	7·79	7·75	5
	100·18	99·44	99
	Berzelius.	Klapr.	Klapr.

TORTOISE-SHELL, resembles the nails of animals or coagulated albumen in its composition. After being reduced to ashes 500 parts leave three of earthy matter, consisting of phosphate of lime with soda and a little iron.

TOUCHSTONE. A variety of flinty slate.

TOURMALINE. Colours green and brown. In prismatic concretions, rolled pieces, but generally crystallized. Crystals imbedded. Splendent, vitreous. Cleavage threefold. Opaque to transparent. Refracts double. As hard as quartz. Easily frangible. Sp. gr. 3·0 to 3·2. By friction it yields vitreous electricity; by heating, vitreous at one end, and resinous at the other. Its constituents are, silica 42, alumina 40, soda 10, oxide of manganese, with a little iron, 7, loss 1. It occurs in gneiss, mica-slate, talc-slate, &c.

TRAGACANTH (Gum). This substance, which is vulgarly called gum-dragon, exudes from a prickly bush, the astragalus tragacantha, Lin. which grows wild in the warmer climates, and endures the cold of our own, but does not here yield any gum. This commodity is brought chiefly from Turkey, in irregular lumps, or long vermicular pieces bent into a variety of shapes; the best sort is white, semi-transparent, dry, yet somewhat soft to the touch. Gum-tragacanth differs from all the other known gums in giving a thick consistence to a much larger quantity of water; and in being much more difficultly soluble, or rather dissolving only imperfectly. Put into water, it slowly imbibes a great quantity of the liquid, swells into a large volume, and forms a soft but not fluid mucilage; if more water be added, a fluid solution may be obtained by agitation: but the liquor looks turbid and wheyish, and on standing, the mucilage subsides, the limpid water on the surface retaining little of the gum. Nor does the admixture of the preceding more soluble gums promote its union with the water, or render its dissolution more durable: when gum-tragacanth and gum-arabic are dissolved together in water, the tragacanth seems to separate from the mixture more speedily than when dissolved by itself. Tragacanth is usually preferred to the other gums for making up troches, and other like purposes, and is supposed likewise to be the most effectual as a medicine; but on account of its imperfect solubility, is unfit for liquid forms. It is commonly given in powder with the addition of other materials of similar intention; thus, to one part of gum-tragacanth, are added one of gum-arabic, one of starch, and six of sugar. See *Cerasin*.

TRANSITION ROCKS, are particularly distinguished as being the lowest in which fossil remains of animals or vegetables are found: they may be regarded as ancient records imprinted with the natural history of the first inhabitants of the globe. We learn from the organic remains and impressions which these rocks contain, that zoophytes and shell-fish, which are considered as forming the lowest link in the scale of animal creation, were the first that received the gift of life. In the rocks above

Trap veins traversing Limestone in [illegible]

these remains of animals occur which possessed a more complex organization with the addition of the faculties of sight and locomotion. Transition rocks contain, like the primary metallic ores, and like the secondary rocks, water-worn pieces of other rocks and organic remains. Hence geologists frequently find a difficulty in determining to what class they shall assign particular rocks, in conformity to their favorite theories.

TRAP, is derived from the Swedish word *trappa*, a stair. It is applied in geology chiefly to such rocks as are frequently seen rising in regular order above one another in the form of stairs, as basalt. The chief trap rocks are hornblende, which is subdivided into granular hornblende and hornblende slate. There is also hornblende mixed with felspar, of which greenstone and greenstone slate are common subdivisions. Also hornblende mixed with mica. The transition trap consists of greenstone and amygdaloed. The newest fletz-trap of the Wernerians, contains several characteristic rocks, as basalt, wacke, greystone, porphyry, slate, and trap-tuff.

TRAP-TUFF. It is composed of masses of basalt, amygdaloid, hornblende rock, sand-stone, and even pieces of wood (as in the island of Canna) cemented together. The masses vary much in size, from that of a pea to several hundred weight. A considerable portion of Arthur's-seat, near Edinburgh, is composed of this rock.

TREMOLITE. This sub-species of augite is divided into the asbestous, common, and glassy.

Asbestous tremolite.—Colour, greyish-white. Massive, and in fibrous concretions. Shining, pearly. Translucent on the edges. Soft. When struck gently or rubbed in the dark, it emits a pale reddish light; when pounded and thrown on the coals, a greenish light. Before the blow-pipe it melts into a white opaque mass.

Common tremolite.—Colour, white. Massive, in distinct prismatic concretions, and crystallized in very oblique four-sided prisms. Translucent. As hard as hornblende. Sp. gr. 2·9 to 3·2. It melts with much difficulty and ebullition into an opaque glass. Its constituents are, silica 50, magnesia 25, lime 18, carbonic acid and water 5.

Glassy tremolite.—Colour, greyish, greenish, yellowish, and reddish-white. As hard as hornblende. Very brittle. Sp. gr. 2·863. It is phosphurescent in a low degree. Infusible. Its constituents are, silica 35·5, lime 26·5, magnesia 16·5, water and carbonic acid 23.

TRIPHANE. See *Spodumene*.

TRIPOLI. Colour, yellowish-grey. Massive. Fracture fine or coarse earthy. Opaque. Soft. Rather easily frangible. Meagre. Does not adhere to the tongue. Sp. gr. 2·2. Infusible. Its constituents are, silica 81, alumina 1·5, oxide of iron 8, sulphuric acid 3·45, water 4·55.

TUNGSTENUM. This name, signifying heavy stone, was given by the Swedes to a mineral, which Scheele found to contain a peculiar metal, as he supposed, in the state of an acid, united with lime. The same metallic substance was afterwards found by the Don d'Elhuyarts united with iron and manganese in wolfram. From the first of these the oxide may be obtained by digesting its powder in thrice its weight of nitric acid; washing the yellow powder that remains, and digesting it in ammonia, by which a portion of it is dissolved. These alternate digestions are to be repeated, and the tungstic oxide precipitated from the ammoniacal solutions by nitric acid. The precipitate is to be washed with water, and exposed to a moderate heat, to expel any ammonia that may adhere to it. Or the mixture may be evaporated to a dry mass, which is to be calcined under a muffle, to dissipate the nitrate of ammonia. From wolfram it may be obtained by the same process, after the iron and manganese have been dissolved by muriatic acid. The Spanish chemists reduced the oxide of tungsten to the metallic state, by exposing it moistened with oil, in a crucible lined with charcoal, to an intense heat. After two hours, a piece of metal weighing 40 grains, but slightly agglutinated, was found at the bottom of the crucible. Some have attempted its reduction in vain, but Guyton, Ruprecht, and Messrs. Aikin and Allen, have been more successful. The latter gentlemen produced it from the ammoniuret. From

240 grains of this substance, in acicular crystals, exposed for two hours to a powerful wind furnace, in a crucible lined with charcoal, they obtained a slightly cohering mass of roundish grains, about the size of a pin's head, with a very brilliant metallic lustre, and weighing, in the whole, 161 grains. Tungsten is said to be of a greyish-white or iron colour, with considerable brilliancy, very hard and brittle. Its specific gravity Don d'Elhuyarts foundeto be 17·6. Messrs. Aikin and Allen, above 17·22. Scheele supposed the white powder obtained by digesting the ore in an acid, adding ammonia to the residuum, and neutralizing it by nitric acid, to be pure acid of tungsten. In fact it has a sour taste, reddens litmus, forms neutral crystallizable salts with alkalis, and is soluble in 20 parts of boiling water. It appears however to be a triple salt, composed of nitric acid ammonia, and oxide of tungsten; from which the oxide may be obtained in a yellow powder by boiling with a pure concentrated acid. In this state it contains about 20 per cent. of oxygen; part of which may be expelled by a red heat, when it assumes a green colour. Tungsten is insoluble in the acids; and its oxide is nearly the same. It appears to be capable of uniting with most other metals, but not with sulphur. Guyton found, that the oxide gives great permanence to vegetable colours.

TUNGSTEN OF BASTNAS, OR FALSE TUNGSTEN. See *Cerium*.

TURBETH MINERAL. Yellow sub-deutosulphate of mercury.

TURNSOLE. Helіotropium. See *Archil*.

TURKEY STONE. Cos Turcica. See *Whetslate*.

TURMERIC *(terra merita) curcuma longa*, is a root brought to us from the East Indies. Berthollet had an opportunity of examining some turmeric that came from Tobago, which was superior to that which is met with in commerce, both in the size of the roots and the abundance of the colouring particles. This substance is very rich in colour, and there is no other which gives a yellow colour of such brightness; but it possesses no durability, nor can mordants give it a sufficient degree. Common salt and sal ammoniac, are those which fix the colour best, but they render it deeper and make it incline to brown; some recommend a small quantity of muriatic acid. The root must be reduced to powder to be fit for use. It is sometimes employed to give the yellows made with weld a gold cast, and to give an orange tinge to scarlet; but the shade the turmeric imparts soon disappears in the air. Mr Guehliche gives two processes for fixing the colour of turmeric on silk. The first consists in aluming in the cold for twelve hours, a pound of silk in a solution of two ounces of alum, and dyeing it hot, but without boiling, in a bath composed of two ounces of turmeric and a quart (measure) of aceto-citric acid, mixed with three quarts of water. The second process consists in extracting the colouring particles from the turmeric by aceto-citric acid, in the way described for Brazil wood, and in dyeing the silk alumed as already mentioned in this liquor, either cold or only moderately warm. The colour is rendered more durable by this than by the former process. The first parcel immersed acquires a gold yellow; the colour of the second and third parcels is lighter, but of the same kind; that of the fourth is a straw colour. Mr. Guehliche employs the same process to extract fine and durable colours from fustic, broom, and French berries; he prepares the wool by a slight aluming, to which he adds a little muriatic acid. He seems to content himself in these cases with vinegar or some other vegetable acid, instead of his aceto-citric acid, for the extraction of the colour: he directs that a very small quantity of solution of tin should be put into the dye-bath.

TURNIPS, carrots, and parsnips, afford principally saccharine, mucilaginous, and extractive matter. Sir H. Davy obtained from 1000 parts of common turnips, seven parts of mucilage, 34 of saccharine matter, and nearly one part of albumen. 1000 parts of carrots furnished 95 parts of sugar, three parts of mucilage, and half part of extract. 1000 parts of parsnip afforded 90 parts of saccharine matter, and nine parts of mucilage. The Walcheren or white carrot, gave in 1000 parts, 98 parts

of sugar, two parts of mucilage, and one of extract.

TURPENTINE is a resinous juice extracted from several trees. Sixteen *ounces of Venice turpentine, being* distilled with water, yielded four ounces and three drachms of essential oil: and the same quantity, distilled without water, yielded with the heat of a water-bath, two ounces only. When turpentine is distilled or boiled with water till it becomes solid, it appears yellowish; when the process is farther continued, it acquires a reddish-brown colour. On distilling sixteen ounces in a retort with an open fire, increased by degrees, Neumann obtained, first, four ounces of a limpid colourless oil; then two ounces and a drachm of a dark brownish-red empyreumatic oil, of the consistence of a balsam, and commonly distinguished by that name. The essential oil, commonly called spirit of turpentine, cannot, without singular difficulty, be dissolved in alcohol, though turpentine itself is easily soluble in that spirit. One part of the oil may be dissolved in seven parts of alcohol; but on standing a while, the greatest part of the oil separates and falls to the bottom.

TURQUOIS, (Mineral, or Calaite). Colours, smalt-blue and apple-green. Fracture conchoidal or uneven. Opaque. Harder than felspar, but softer than quartz. Streak white. Sp. gr. 2·86 to 3·0. Its constituents are, alumina 73, oxide of copper 4·5, water 18, oxide of iron 4. It is very highly prized as an ornamental stone in Persia, and the neighbouring countries. Bone turquois is phosphate of lime, coloured with oxide of copper.

TUTENAG. This name is given in India to the metal zinc. It is sometimes applied to denote a white metallic compound, brought from China, called also Chinese copper, the art of making which, is not known in Europe. It is very tough, strong, malleable, may be easily cast, hammered, and polished; and the better kinds of it, when well manufactured, are very white, and not more disposed to tarnish than silver is. Three ingredients of this compound may be discovered by analysis; namely, copper, zinc, and iron. Some of the Chinese white copper is said to be merely copper and arsenic.

TYPE METAL. The basis of type metal for printers, is lead, and the principal article used in communicating hardness, is antimony, to which copper and brass in various proportions are added. The properties of a good type metal are, that it should run freely into the mould, and possess hardness without being excessively brittle. The smaller letters are made of a harder composition than those of a larger size. It does not appear that our type founders are in possession of a good composition for this purpose. The principal defect of their composition appears to be, that the metals do not uniformly unite. In a piece of casting performed at one of our principal founderies, the thickness of which was two inches, one side was hard and brittle when scraped, and the other side, consisting of nearly half the piece, was soft like lead. The transition from soft to hard was sudden, not gradual. If a parcel of letter of the same size and casting be examined, some of them are brittle and hard, and resist the knife, but others may be bent and cut into shavings. It may easily be imagined, that the duration and neatness of these types must considerably vary.*

U.

ULMIN. Dr. Thomson has given this temporary name to a very singular substance lately examined by Klaproth. It differs essentially from every other known body, and must therefore constitute a new and peculiar vegetable principle. It exuded spontaneously from the trunk of a species of elm, which Klaproth conjectures to be the ulmus nigra, and was sent to him from Palermo in 1802. 1. In its external characters it resembles gum. It was solid, hard, of a black colour, and had considerable lustre. Its powder was brown. It dissolved readily in the mouth, and

was insipid. 2. It dissolved speedily in a small quantity of water. The solution was transparent, of a blackish brown colour, and, even when very much concentrated by evaporation, was not in the least mucilaginous or ropy; nor did it answer as a paste. In this respect, ulmin differs essentially from gum. 3. It was completely insoluble both in alcohol and ether. When alcohol was poured into the aqueous solution, the greatest part of the ulmin precipitated in light brown flakes. The remainder was obtained by evaporation, and was not sensibly soluble in alcohol. The alcohol by this treatment acquired a sharpish taste. 4. When a few drops of nitric acid were added to the aqueous solution, it became gelatinous, lost its blackish brown colour, and a light brown substance precipitated. The whole solution was slowly evaporated to dryness, and the reddish brown powder which remained was treated with alcohol The alcohol assumed a golden-yellow colour; and when evaporated, left a light brown, bitter and sharp resinous substance. 5. Oxymuriatic acid produced precisely the same effects as nitric. Thus it appears that ulmin, by the addition of a little oxygen, is converted into a resinous substance. In this new state it is insoluble in water. This property is very singular. Hitherto, the volatile oils were the only substances known to assume the form of resins. That a substance soluble in water should assume the resinous form with such facility, is very remarkable. 6. Ulmin when burnt emitted little smoke or flame, and left a spongy but firm charcoal, which, when burnt in the open air, left only a little carbonate of potash behind. Such are the properties of this curious substance, as far as they have been examined by Klaproth.

URANGLIMMER. An ore of uranium. formerly called green mica, and by Werner chalcolite. See the following article.

URANITE, or URANIUM. A new metallic substance, discovered by the celebrated Klaproth in the mineral called Pechblende. In this it is in the state of sulphuret. But it likewise occurs as an oxide in the green mica, or uranglimmer, and in the uranochre. By treating the ores of the metal with the nitric or nitromuriatic acid, the oxide will be dissolved, and may be precipitated by the addition of a caustic alkali. It is insoluble in water, and of a yellow colour, but a strong heat renders it of a brownish grey. To obtain it pure, the ore should be treated with nitric acid, the solution evaporated to dryness, and the residuum heated, so as to render any iron it may contain insoluble. This being treated with distilled water, ammonia is to be poured into the solution, and digested with it for some time, which will precipitate the uranium and retain the copper. The precipitate, well washed with ammonia, is to be dissolved in nitric acid, and crystallized. The green crystals, dried on blotting paper, are to be dissolved in water, and recrystallized, so as to get rid of the lime. Lastly, the nitrate, being exposed to a red heat, will be converted into the yellow oxide of uranium. It is very difficult of reduction. Fifty grains, after being ignited, were formed into a ball with wax, and exposed, in a well closed charcoal crucible, to the most vehement heat of a porcelain furnace, the intensity of which gave 170° on Wedgwood's pyrometer. Thus a metallic button was obtained, weighing 28 grains, of a dark grey colour, hard, firmly cohering, fine grained, of very minute pores, and externally glittering. On filing it, or rubbing it with another hard body, the metallic lustre has an iron-grey colour; but in less perfect assays it verges to a brown. Its specific gravity was 8·1. Bucholz, however, obtained it as high 9·0. There is probably but two oxides of uranium, the protoxide, which is greyish black, and the peroxide, which is yellow. The oxide is soluble in dilute sulphuric acid gently heated, and affords lemon-coloured prismatic crystals. It combines with vitrifiable substances, and gives them a brown or green colour. On porcelain, with the usual flux, it produces an orange.

URANOCHRE. An ore of uranium, containing this metal in the oxidized state.

URATES. Compounds of uric or lithic acid, with the salifiable bases.

UREA, is a substance found in

urine, which has been analyzed by Dr. Prout and M. Berard. The results are nearly the same.

Hydrogen	10·80	-	6·66
Carbon	19·40	-	19·99
Oxygen	26·40	-	26·66
Azote	43·40	-	46·66
	100·00	-	100·00

Urea and Uric acid are very different in their composition, but they agree in being the most azotized of all animal substances, and the secretion of urine appears to have for its object the separation of the excess of azote from the blood, as respiration seperates from it the excess of carbon. Urea may be thus prepared: evaporate urine to the consistence of syrup, add gradually to the syrup its volume of nitric acid, stir the mixture and immerse in a bath of iced water to harden the crystals of the acidulated nitrate of urea, which precipitate; wash these crystals with ice cold water, and press them between the folds of blotting paper; re-dissolve these crystals, and add a sufficient quantity of carbonate of potash to neutralize the nitric acid; evaporate the new liquor, and treat the residuum with pure alcohol, which redissolves only the urea. On concentrating the alcohol solution, the urea crystallizes. Urea crytallizes in four-sided prisms, transparent, colourless, with a slightly pearly lustre. It has a peculiar, but not urinous odour; it does not affect litmus or turmeric paper; it undergoes no change from the atmosphere, except a slight deliquescence in damp weather; it melts in a strong heat; it is very soluble in water; specific gravity of the crystals 1·35. The fixed alkalis and alkaline earths decompose it. It unites with most of the metallic oxides, and forms crystalline compounds with the nitric and oxalic acids. If cautiously introduced into a retort with a wide short neck, it fuses with a gentle heat: a white fume rises, which is benzoic acid, and condenses on the sides of the receiver: crystallized carbonate of ammonia succeeds, and continues to the end: neither water nor oil rises, but the sublimate is turned brown: the air expelled from the apparatus is impregnated with a smell of garlic and stinking fish: when the heat is very intense, the smell is insupportable. The matter in the retort is then dry, blackish, and covered with a raised white crust, which rises at length in a heavy vapour, and attaches itself to the lower part of the retort. This is muriate of ammonia. If water be poured on the residuum, it emits a smell of prussic acid. Burned on an open fire it exhales the same smell, gives out ammonia, and leaves one-hundredth of its weight of acrid white ashes, which turn syrup of violets green, and contain a small quantity of carbonate of soda. The aqueous solution, distilled by a gentle fire, and carried to ebullition, affords very clear water loaded with ammonia. By adding more water, as the liquor became inspissated, Fourcroy and Vauquelin obtained nearly two-thirds of the weight of the urea in carbonate of ammonia, and the residuum was not then exhausted of it. The latter portions, however, were more and more coloured This decomposition of an animal substance, at the low heat of boiling water, is very remarkable, particularly with respect to the carbonic acid. Indeed, it appears that a very slight change of equilibrium is sufficient to cause its constituent principles to pass into the state of ammonia, and carbonic, prussic, and acetous acids. Urea has a singular effect on the crystallization of some salts. If muriate of soda be dissolved in a solution of urea, it will crystallize by evaporation, not in cubes, but in octaëdra; muriate of ammonia, on the contrary, treated in the same way, instead of crystallizing in octaëdra, will assume the cubic form. The same effect is produced, if fresh urine be employed.

URIC ACID. See *Lithic Acid.*

URINE. This excrementitious fluid, in its natural state, is transparent, of a yellow colour, a peculiar smell and saline taste. Its production as to quantity, and in some measure quality, depends on the seasons and the peculiar constitution of the individual, and is likewise modified by disease. It is observed, that perspiration carries off more or less of the fluid, which would else have passed off by urine; so that the profusion of the former is attended with a diminution of the latter. From the alkaline smell of urine kept for a certain

time, and other circumstances, it was formerly supposed to be an alkaline fluid; but by its reddening paper stained blue with litmus or the juice of raddishes, it appears to contain an excess of acid. The numerous researches made concerning urine have given the following as its component parts;—1, water; 2, urea; 3, phosphoric acid; 4, 5, 6, 7, phosphates of lime, magnesia, soda, and ammonia; 8, 9, 10, 11, lithic, rosacic, benzoic, and carbonic acid; 12, carbonate of lime; 13, 14, muriates of soda and ammonia; 15, gelatin; 16, albumen; 17, resin; 18, sulphur.—Muriate of potash may sometimes be detected in urine, by cautiously dropping into it some tartaric acid; as may sulphate of soda, or of lime, by a solution of muriate of barytes, which will throw down sulphate of barytes together with its phosphate; and these may be separated by a sufficient quantity of muriatic acid, which will take up the latter.—Urine soon undergoes spontaneous changes, which are more or less speedy and extensive, according to its state, as well as the temperature of the air. Its smell, when fresh made, and healthy, is somewhat fragrant; but this presently goes off, and is succeeded by a peculiar odour termed urinous. As it begins to be decomposed, its smell is not very unlike that of sour milk; but this soon changes to a fœtid, alkaline odour. It must be observed, however, that turpentine, asparagus, and many other vegetable substances, taken as medicine, or used as food, have a very powerful effect on the smell of the urine. Its tendency to putrefaction depends almost wholly on the quantity of gelatin and albumen it contains; in many cases, where these are abundant, it comes on very quickly indeed. The changes produced in urine by disease are considerable, and of importance to be known. It is of a red colour, small in quantity, and peculiarly acrid, in inflammatory diseases; but deposits no sediment on standing. Corrosive muriate of mercury throws down from it a copious precipitate. Toward the termination of such diseases, it becomes more abundant, and deposits a copious pink-coloured sediment, consisting of rosacic acid, with a little phosphate of lime and uric acid. In jaundice it contains a deep yellow-colouring matter, capable of staining linen. Muriatic acid renders it green, and this indicates the presence of bile. Sometimes, too, according to Fourcroy and Vauquelin, it contains a substance analogous to the yellow acid, which they formed by the action of nitric acid on muscular fibre.—In hysterical affections it is copious, limpid, and colourless, containing much salt, but scarcely any urea or gelatin. In dropsy the urine is generally loaded with albumen, so as to become milky, or even coagulate by heat, or on the addition of acids. In dropsy from diseased liver, however, no albumen is present; but the urine is scanty, high coloured, and deposits the pink-coloured sediment. In dyspepsy, or indigestion, the urine abounds in gelatin, and putrefies rapidly. In rickets the urine contains a great deal of a calcareous salt, which has been supposed to be phosphate of lime, but, according to Bonhomme, it is the oxalate.—Some instances are mentioned, in which females have voided urine of a milky appearance, and containing a certain portion of the caseous part of milk. But among the most remarkable alterations of urine is that in the diabetes, when the urine is sometimes so loaded with sugar, as to be capable of being fermented into a vinous liquor. Upwards of one-twelfth of its weight of sugar was extracted from some diabetic urine by Cruikshank, which was at the rate of twenty-nine ounces troy a day from one patient. In this disease, however, the urine, though always in very large quantity, is sometimes not sweet, but insipid. The urine of some animals, examined by Fourcroy, Vauquelin, and Rouelle, jun. appears to differ from that of man in wanting the phosphoric and lithic acids, and containing the benzoic. That of the horse, according to the former two, consists of benzoate of soda ·024, carbonate of lime ·011, carbonate of soda ·009, muriate of potash ·009, urea ·007, water and mucilage ·940. Giese, however, observes, that the proportion of benzoate of soda varies greatly, so that sometimes scarcely any can be found. Notwithstanding the assertions of these chemists, that the urine of the horse contains no phosphoric acid,

Giobert affirms that phosphorus may be made from it. That of the cow, according to Rouelle, contains carbonate, sulphate, and muriate of potash, benzoic acid, and urea: that of the camel differed from it in affording no benzoic acid: that of the rabbit, according to Vauquelin, contains the carbonates of lime, magnesia, and potash, sulphates of potash and lime, muriate of potash, urea, gelatin, and sulphur. All these appear to contain some free alkali, as they turn syrup of violets green. In the urine of domestic fowls, Fourcroy and Vauquelin found lithic acid. —Urine has been employed for making phosphorus, volatile alkali, and sal ammoniac; moulds to the produce of nitre-beds; and it is very useful in a putrid state for scouring woollens.

URINARY CALCULI. A true explanation of the nature of urinary calculi was quite impossible before chemistry had made considerable progress, and the method of analysis had advanced a great way towards perfection; and, as will appear in the course of this article, all the valuable knowledge which now exists upon this subject is, in reality, the fruit of modern investigations. It is to be regretted, however, that our information, on many points, is far from being settled or complete, as any impartial and judicious reader may soon convince himself, by a reference to the able and scientific views lately taken by Dr. Prout, of various questions relative to the formation of gravel and calculi, and the treatment of such cases in all their varieties. Mechanical deposites from the urine are divided by Dr. Prout into three classes:—1st. Pulverulent, or amorphous sediments. 2nd. Crystalline sediments, usually denominated gravel. 3d. Solid concretions, or calculi, formed by the aggregation of these sediments. Pulverulent, or amorphous sediments, are described by Dr. Prout as almost always existing in a state of solution in the urine before it is discharged, and even afterwards, until it begins to cool, when they are deposited in the state of a fine powder, the particles of which do not appear to be crystalline. Their colour is, for the most part, brown or yellow, and generally speaking, they consist of two species of neutral saline compounds; viz., the lithates of ammonia, soda, and lime, tinged more or less with the colouring principle of the urine, and with the purpurates of the same bases, and constituting what are usually denominated pink and lateritious sediments; and secondly, the earthy phosphates, namely, the phosphate of lime, and the treble phosphate of magnesia and ammonia, constituting, for the most part, sediments nearly white. The two species of sediments are frequently mixed together, though the lithates generally prevail. Crystalline sediments or gravel are commonly voided in the form of minute angular grains, or crystals, composed, 1st, of lithic acid, nearly pure; 2nd, of triple phosphate of magnesia and ammonia; and 3d, of oxalate of lime. The crystals of lithic acid which are by far the most frequent, are always more or less of a red colour. It is further remarked by Dr. Prout, that these different varieties of crystalline deposites are never voided together, though they not unfrequently occur with amorphous sediments. Solid concretions, or urinary calculi, arising from the precipitation and consolidation of the urinary sediments, may be formed in any of the cavities to which the urine has access; and hence they are met with in the kidneys, ureters, bladder, and urethra. Their various appearances and chemical properties will be presently described. Most of them are believed to be originally produced in the kidneys, from which they afterwards descend with the urine. To this statement, however, the cases in which calculi are formed upon foreign bodies, introduced into the bladder, are manifest exceptions. In the centre of urinary calculi, bullets, splinters of bone, pieces of bougies, and wood, pins, needles, nuts, &c. are frequently observed; and it would appear that a very minute substance is capable of becoming a nucleus: a mere clot of blood, or a little bit of chaff, if not soon voided, being sufficient to lead to the formation of a stone in the bladder. The lithic acid itself is a common nucleus, even where the whole calculi is not of the same material. It would appear then, that Scheele first discovered the nature of those urinary calculi which consist of lithic acid, but that Dr.

Wollaston first ascertained the nature of several other kinds, some of which have also been described at a later period by Fourcroy and Vauquelin. On the whole, there are five species of concretions, where chemical properties were first pointed out by Dr. Wollaston, and no less than four belong to the urinary organs. These are, 1st. Gouty concretions; 2dly, the fusible calculus; 3dly, the mulberry calculus; 4thly, the calculus of the prostate gland; 5thly, the cystic oxide discovered in 1810.

1. Lithic acid calculus.—Dr. Prout believes, that at least two-thirds of the whole number of calculi originate from lithic acid; for as it forms by far the most common nucleus round which other calculous matter is subsequently deposited, if such nuclei had not been formed and detained, two persons at least out of three, who suffer from stone, would never have been troubled with the disorder. Lithic acid forms a hard inodorous concretion, of a yellowish or brown colour, similar to that of wood of various shades. According to professor Murray, calculi of this kind are in fine close layers, fibrous, or radiated, and generally smooth on their surface, though sometimes a little rough. They are rather brittle, and have a specific gravity varying from 1·276 to 1·786, but usually above 1·500. One part of lithic acid is said to dissolve in 1720 parts of cold water, and this solution turns vegetable blues to a red colour. When it has been dissolved in boiling water, small yellowish crystals are deposited as the fluid becomes cold. Lithic acid in calculi blacken, but are not melted by the blow-pipe, emitting a peculiar animal smell, and gradually evaporating, until a small quantity of white ash remains, which is alkaline. By distillation they yield ammonia and prussic acid. They are soluble in the cold in a solution of pure potassa or soda: from the solution, a precipitate of a fine white powder is thrown down by the acid. Lime water likewise dissolves them, but more sparingly. According to Scheele they remain unchanged in solutions of the alkaline carbonates, a statement which agrees with that of Dr. Prout, who accounts for the effect said to be produced by the alkaline carbonates upon calculi in the bladder, by their property of dissolving the lithate of ammonia. They are not much acted upon by ammonia. They are not soluble either in the muriatic or sulphuric acid, though they are so in the nitric when assisted by heat, and the residue of the solution, when evaporated to dryness, assumes a remarkably bright pink colour, which disappears on adding either an acid or an alkali. In many of these calculi, the lithic acid is nearly pure; in others there is an intermixture of other ingredients, particularly of phosphate of lime, and phosphate of ammonia and magnesia, and in almost all of them there is a portion of animal matter, which occasions the smell when they are burnt, and the loss in their analysis. *A great quantity of uric acid is formed in gouty constitutions, and deposited in the joints or soft parts in the state of lithate of ammonia.* Sir Everard Home removed a tumor, weighing four ounces, from the heel of a gentleman, a martyr to the gout; and when analysed by professor Brande, it was found to be principally composed of uric acid.

2. Lithate of ammonia calculus, according to Dr. Prout, is generally of the colour of clay. Its surface is sometimes smooth, sometimes tuberculated. It is composed of concentric layers, and its fracture resembles that of compact limestone. It is generally of small size, and rather uncommon; but the lithate of ammonia very frequently occurs mixed with lithic acid, forming a mixed variety of calculus. Under the flame of the blow pipe it usually decrepitates strongly. It is much more soluble in water than the lithic acid calculus, and always gives off a strong smell of ammonia on being heated with caustic potash. The lithate of ammonia is also readily soluble in the alkaline subcarbonates, which pure lithic acid is not.

3. Bone earth phosphate of lime calculus.—The presence of the phosphate of lime in urinary calculi had been mentioned by Bergmann and others, when Dr. Wollaston first ascertained that some calculi are entirely composed of it. From the investigation of Dr. Wollaston, it appears that this substance sometimes,

though rarely, composes the entire calculus; but that in *general* it is mixed with other ingredients, particularly with uric acid and phosphate of magnesia and ammonia. In the first case, the calculus is described as being of a pale brown colour, and so smooth as to appear polished. When sawn through, it is found very regularly laminated, and the laminæ, in general, adheres so slightly to each other, as to separate with ease into concentric crusts. It dissolves entirely, though slowly, in muriatic or nitric acid. Exposed to the flame of the blow-pipe, it is at first slightly charred, but soon becomes perfectly white, retaining its form until urged with the utmost heat from a common blow-pipe, when it may be completely fused. It appears to be more fusible than the phosphate of lime which forms the basis of bone, a circumstance which Dr. Wollaston ascribes to the latter containing a larger quantity of lime.

4. Triple phosphate of magnesia and ammonia calculus.—The existence of this calculus in the intestines of animals was first pointed out by Fourcroy, but its being a constituent part of some urinary calculi of the human subject, was originally discovered by Dr. Wollaston. According to Dr. Prout, this species of calculus is always nearly white; its surface is commonly uneven, and covered with minute shining crystals. Its texture is not laminated, and it is easily broken and reduced to powder. In some rare instances, however, it is hard and compact, and when broken, exhibits a crystalline texture, and is more or less transparent. Calculi, composed entirely of the phosphate of magnesia and ammonia, are rare; but specimens in which they constitute the predominant ingredient are by no means uncommon. When the blow-pipe is applied, an ammoniacal smell is perceived, the fragment diminishes in size, and if the heat be strongly urged, it absolutely undergoes an imperfect fusion, being reduced to the state of phosphate of magnesia. Dr. Wollaston describes the form of the crystals of this salt as being a short trilateral prism, having one angle, a right angle, and the other two equal, terminated by a pyramid of three or six sides. These crystals, as Dr. Marcet has explained, are but very *sparingly soluble* in water, but very readily in most, if not all, the acids; and on precipitation, they resume the crystalline form. From the solution of these crystals in muriatic acid, sal ammoniac may be obtained by sublimation. Solution of caustic alkali disengages ammonia from the triple salt, the alkali combining with a portion of the phosphoric acid.

5. Fusible calculus.—Mr. Tennant first discovered that this substance was different from the lithic acid, and that when urged by the blow-pipe, instead of being nearly consumed, a large part of it melted into a white vitreous globule. The nature of the fusible calculus was afterwards more fully investigated and explained by Dr. Wollaston. According to the excellent description lately given of this calculus by Dr. Marcet, it is commonly whiter, and more friable, than any other species. It sometimes resembles a mass of chalk, leaving a white dust on the fingers, and separates easily into layers or laminæ; the interstices of which are often studded with sparkling crystals of the triple phosphate. At other times it appears in the form of a spongy and very friable whitish mass, in which the laminated structure is not obvious. Calculi of this kind often acquired a very large size, and they are apt to mould themselves in the contracted cavity of the bladder, assuming a peculiarity of form which Dr. Marcet has never observed in any of the other species of calculi, and which consists in the stone, terminating at its broader end in a kind of peduncle corresponding to the neck of the bladder. The chemical composition of the fusible calculus is a mixture of the triple phosphate of magnesia and ammonia, and of the phosphate of lime. These two salts, which, when separate, are infusible, or nearly so, when mixed together and urged by the blow-pipe, easily run into a vitreous globule. The composition of this substance, says Dr. Marcet, may be shown in various ways: thus, if it be pulverized, and acetic acid poured upon it, the triple crystals will be readily dissolved, while the phosphate of lime will scarcely be acted upon; after which,

the muriatic acid will readily dissolve the latter phosphate, leaving a small residue consisting of lithic acid, a portion of which is always found mixed with the fusible calculus. It is also remarked by Dr. Marcet, that many of the calculi which form round extraneous bodies in the bladder, are of the fusible kind; and the calculus matter sometimes deposited between the prepuce and glands, is found to be of the same nature.

6. Mulberry calculus, or oxalate of lime, is mostly of a dark brown colour, its interior being often grey. Its surface is usually uneven, presenting tubercles more or less prominent, frequently rounded, sometimes pointed, and either rough or polished. It is very hard, difficult to saw, and appears to consist of successive unequal layers: excepting the few stones which contain a proportion of silica, it is the heaviest of the urinary concretions. Though this calculus has been named mulberry, from its resemblance to that fruit, yet, as Dr. Marcet has observed, there are many concretions of this class which, far from having the mulberry appearance, are remarkably smooth and pale coloured. According to Mr. Brande, persons who have voided this species of calculus are much less liable to a return of the complaint than other patients who discharge lithic calculi. With regard to chemical characters, says professor Murray, it is less affected by the application of the usual reagents than any other calculus. The pure alkaline solutions have no effect upon it, and the acids dissolve it with great difficulty. When it is reduced, however, to fine powder, both muriatic and nitric acids dissolve it slowly. The solutions of the alkaline carbonates decompose it, as Fourcroy and Vauquelin have observed, and this affords us the easiest method of analyzing it. The calculus, in powder, being digested in the solution, carbonate of lime is soon formed, which remains insoluble, and is easily distinguished by the effervescence produced by the addition of weak acetic acid, while there is obtained in solution the compound of oxalic acid with the alkali of the alkaline carbonate. From this the oxalic acid may be precipitated by the acetate of lead of barytes, and this oxalate thus formed, may be afterwards decomposed by sulphuric acid. Another method of analysing this calculus is, by exposure to heat its acid is decomposed, and by raising the heat sufficiently, pure lime is obtained, amounting to about a third of the weight of the calculus. According to Fourcroy and Vauquelin, the oxalate of lime calculus contains more animal matter than any other. This animal matter appeared to them to be a mixture of albumen and urea. The composition of a calculus of this species, analysed by Mr. Brande, was oxalate of lime 65 grains, uric acid 16 grains, phosphate of lime 15 grains, animal matter 4 grains.

7. The cystic oxide calculus is small and very rare. It was described by Dr. Wollaston (Phil. Trans. for 1810). In external appearance it bears a greater resemblance to the triple phosphate of magnesia than any other sort of calculus; however, it is more compact, and does not consist of distinct laminæ, but appears as one mass confusedly crystallized throughout its substance. It has a yellowish semi-transparency, and a peculiar glistening lustre. Under the blow-pipe it gives a singular fœtid smell, quite different from that of lithic acid, or the smell of prussic acid. In consequence of the readiness with which this species of calculus unites both with acids and alkalies, in common with other oxides, and the fact of its also containing oxygen (as is proved by the formation of carbonic acid by distillation), Dr. Wollaston named it an oxide, and the term cystic was added from its having been originally found only in the bladder in two examples. Dr. Marcet, however, has subsequently met with no less than three instances of calculi formed of cystic oxide, all of which were originally of renal origin.

8. Alternating calculus. Lithic strata frequently alternate with layers of oxalate of lime, or with the phosphates. Sometimes, also, the mulberry alternates with the phosphates, and in a few instances, three, or even four species of calculi, occur in the same stone, disposed in distinct concentric laminæ. On the comparative frequency of these, and other varieties of calculi, Dr. Prout's work contains valuable information.

9. Compound calculi, with their ingredients intimately mixed.—Under this title Dr. Marcet comprehends certain calculi which have no characteristic feature by which they can be considered as distinctly belonging to any of the other classes. He observes, that they may sometimes be recognized by their more or less irregular figure, and their less determinate colour; by their being less distinctly, if at all, divisible into strata, and by their often possessing a considerable hardness. By chemical analysis confused results are obtained. See *Essay on the Chemical and Medical History of Calculous Disorders*, p.99.

10. Calculi of the prostate gland.—The composition of these calculi is said to have been first explained by Dr. Wollaston—(see Phil. Trans. for 1797). They all consist of phosphate of lime, the earth not being redundant, as in bones. Their size varies from that of a pin's head to that of a hazel-nut. Their form is more or less spheroidal, and they are of a yellowish brown colour. Fourcroy has described a species of urinary calculus which is characterised by its being composed of the urate, or lithate of ammonia. Dr. Wollaston, Mr. Brande, and Dr. Marcet, did not, however, satisfactorily ascertain the presence of this substance in any of the concretions which they examined; as also urea and the triple phosphate, both of which afford ammonia, are frequently present in lithic calculi: it is conjectured that these circumstances may have given rise to the analytical results from which the existence of urate of ammonia has been inferred. The recent investigation of Dr. Prout, however, tends to establish the reality of the lithate of ammonia calculus. Dr. Marcet has met with two specimens of urinary calculi, entirely different from any which have hitherto been noticed. One of these he proposes to name xanthic oxide, from ξανθος, yellow, because one of the most characteristic properties is that of forming a lemon-colour compound, when acted upon by nitric acid. The chemical properties of the other new calculus mentioned by Dr. Marcet, correspond to those of fibrine, and he therefore suggests the propriety of distinguishing it by the term fibrinous. For a particular description of these new substances, we must refer to this gentleman's essay.

11. Carbonate of lime calculus. This substance is not enumerated by Dr. Marcet, as entering into the composition of urinary calculi. But according to Mr. R. Smith, there can be no doubt of the fact. Dr. W. H. Gilby, of Clifton, says he detected it decidedly in four instances. A notice of it will be found in Mr. Tilloch's Journal for 1817, Vol. XLIX. p. 188, in the account of a curious calculus, discovered by G. M. Burroughs of Clifton, the nucleus of which is a common cinder, an inch and a half long and one broad. Since the publication of that paper, (continues Mr. Smith), Mr. H Sully, of Wivelscombe, sent me three oddly-shaped calculi which he removed from a lady together with fifteen pea-sized ones previously voided by the urethra, which are entirely carbonate of lime held together by animal mucus.

Whoever has occasion to study the chemical properties of the urine, says Doctor Marcet, will learn, that if any alkali (a few drops of ammonia for instance) be added to recent urine, a white cloud appears, and a sediment, consisting of phosphate of lime, with some ammoniaco-magnesian phosphate, subsides in the proportion of about two grains of the precipitate to about four ounces of urine. Lime-water produces a precipitate of a similar kind, which is still more copious; for the lime, in combining with the excess of phosphoric, and perhaps also of lactic acid, not only precipitates the phosphate of lime which these acids held in solution, but it decomposes the other phosphates, thus generating an additional quantity of the phosphate of lime, which is also deposited. If on the contrary, (observes the same author) a small quantity of any acid, either the phosphoric, the muriatic, or indeed even common vinegar, be added to recent healthy urine, and the mixture be allowed to stand for one or two days, small, reddish crystalline particles of lithic acid will be gradually deposited on the inner surface of the vessel. It is on these two general facts that our principles of chemical treatment ultimately rest. Whenever the lithic secretion predominates, the

alkalies are the appropriate remedies, and the acids, particularly the muriatic, are the agents to be resorted to when the calcareous or magnesian salts prevail in the deposites. The alkalies taken into the stomach certainly reach the urinary passages through the medium of the circulation; and it is also strongly suspected that the acids likewise do so, though this circumstance is still a question. Unfortunately the quantity of either alkalies or acids which thus mixes with the urine is so small, that no impression is made upon calculi of magnitude. The experience of Dr. Marcet, Dr. Prout, and others, however, has clearly ascertained that such medicines are often capable of checking a tendency to the formation of stone, and sometimes of bringing on a calculous deposite, depending upon the altered state of the system. Indeed Dr. Marcet expresses his decided opinion, that even supposing not an atom of alkali or acid ever reached the bladder, still it would not be unreasonable to expect, that those remedies may respectively produce the desired changes during the first stages of assimilation,—in one case by neutralizing any morbid excess of acid in the primæ viæ; and in the other, by checking a tendency to alkalescence or otherwise disturbing those affinities which in the subsequent processes of assimilation and secretion give rise to calculous affections. When muriatic acid is prescribed, from five to twenty-five drops may be given two or three times a-day, diluted with a sufficient quantity of water. The best way of taking the alkalies is by drinking soda water as a common beverage. It is asserted, however, on the authority of Sir G. Blane, that when the alkalies are combined with nitric acid, as in the ordinary saline draught, they also have the effect of depriving the urine of its acid properties. Dr. Marcet, with every appearance of probability, refers to carbonic acid itself having no solvent power, and he does not even adopt Mr. Brande's opinion, that this acid passes into the urine when patients drink fluids impregnated with it. But it may be inquired, if no known internal medicine will dissolve a stone already formed, what is the good of merely altering the diathesis, and checking the increase of the calculus, as lithotomy must still be necessary? The reasons for persevering in the aim of correcting any particular state of the system, and urinary secretion, on which state the increase of a calculus depends, are very important; for it is found, that though medicines may be quite incapable of dissolving a calculus, they relieve a great deal of the distress and suffering, apparently the effect of the diathetic itself, and afford such ease that the operation may be postponed until the health is improved, or in a very old subject, be dispensed with altogether. The aim is also of high importance, with the view of preventing relapses. As the lithic acid diathesis seems to be concerned in the production of about two-thirds of the whole number of the urinary calculi, the correction of it has been a chief aim amongst modern practitioners. For this purpose Magendie, whose experiments tend to prove that the lithic diathesis may be lessened and removed by abstinence from animal food and other nutriments abounding in azote, founds his practice very much upon this alleged fact. His indications, however, are four in number; viz. 1st, To lessen the quantity of uric acid produced by the kidneys. 2d, To augment the secretion of urine; a maxim which leads him to consider cutaneous perspiration injurious,—a statement which we think must be rejected, considering the rarity of calculi in hot climates, independently of the sentiments of Dr. Wilson Philip, that the precipitating acid, (if such be the cause) is thrown by the skin, and consequently, that ensuring a due performance of the cutaneous functions must in these cases be beneficial. (See Med. Trans. of the College of Physicians, Vol VI.) 3d, To prevent the lithic acid from assuming a solid form, by saturating it. 4th, When gravel and calculi are formed, to promote their discharge, and attempt their dissolution. (Recherches, &c. sur la Gravelle, p. 42.) For correcting the lithic acid diathesis, Dr. Prout particularly enjoins the avoidance of errors in diet, exercise, &c. The error of quantity of food he deems worse than the errors of quality. Patients, he says, should abstain altogether from things which manifestly disagree with them, and

which must be unwholesome to all,—such as heavy unfermented bread, hard boiled and fat pudding, salted and dried meats, acescent fruits, and, (if the digestive organs be debilitated) soups of every kind. In general also wine, and particularly those of an acescent quality, should be avoided. The wearing of flannel, the preserving a regular state of the bowels, and the occasional use of alterative medicines, are likewise recommended. At the beginning of the eighteenth century, lime and alkalies were known to be frequently productive of relief in cases of stone; and in particular, the nostrum of a Mrs. Stevens, the active ingredients of which were calcined egg-shells and soap, acquired such celebrity for the cures which it effected, that much anxiety was expressed that her formula should be made public. The consequence was, that in the year 1739 Parliament appointed a committee of twenty-two respectable men to investigate the merits of the remedy in question: and on their favourable report the secret was purchased for the sum of £5000. Mrs. Stevens first gave calcined egg-shells alone; but finding costiveness produced, she added soap. In time she rendered her process more complicated, adding snails burnt to blackness, a decoction of camomile flowers, parsley, sweet fennel, and the greater burdock. That in the lithic acid diathesis, the carbonated fixed alkalies taken in large doses, have the effect of passing into the urine, and saturating the redundant lithic acid in the unhealthy state of that fluid, is a fact decidedly proved. If there were any doubt yet remaining upon this point, it would be immediately removed by the perusal of the case of the celebrated Mascagni, as detailed by himself. Sir E. Home and Mr. Hatchett first suggested the utility of giving magnesia in cases of stone; and the proposal was communicated to the public by Mr. Brande. As Dr. Marcet observes, magnesia is often found advantageous in long protracted cases, in which the constant use of the subcarbonated or caustic alkalies would injure the stomach. But he properly remarks, that if magnesia is sometimes beneficial, it has of late years often done harm. For as this earth is the base of one of the most common species of calculi, viz. that containing the phosphate of ammonia and magnesia, there is nearly an even chance when magnesia is prescribed, without any previous knowledge of the nature of the calculus, that it will prove injurious. Magnesia also, when long and profusely administered, sometimes forms large masses in the intestinal canal, causing serious distress, and even fatal consequences. According to Dr. Prout, purgatives will sometimes stop calculous depositions, especially in children; and Dr. Henry, of Manchester, has observed, that a quack medicine composed of turpentine and opium will occasionally produce a plentiful discharge of lithic acid from the bladder. On the whole, reason and experience will allow us to consider lime-water, soap, acidulous soda water, the carbonate of potassa, the liquor potassæ, and magnesia, only as palliative remedies, by which the pain of the disorder may sometimes be diminished, and the urinary secretion improved; it being more rational to impute the few supposed instances of greater success to the calculi becoming encysted. As medicines taken into the stomach will not dissolve urinary calculi, solvent injections have been introduced through a catheter directly into the bladder. Fourcroy and Vauquelin ascertained, that a ley of potassa or soda, not too strong to be swallowed, softens and dissolves small calculi composed of the uric acid and urate of ammonia, when they are left in the liquid a few days. They proved that a beverage merely acidulated with nitric or muriatic acid dissolves with still greater quickness calculi formed of the phosphate of lime and of the triple phosphate of ammonia and magnesia. They also ascertained, that calculi composed of the oxalate of lime, which are the most difficult of solution, may be softened, and almost quite dissolved in nitric acid greatly diluted, provided they were kept in the mixture a sufficient time. Liquids are then known which will dissolve calculi of various compositions; but much difficulty occurs in employing them effectually in practice; for although they can be easily injected into the bladder, this organ is so extremely tender and irritable, that the action of such liquids

upon it as would be requisite for dissolving a stone, would produce sufferings which no man could endure, and the most dangerous and fatal effects upon the bladder itself. Another objection to this practice arises from the surgeon's never knowing what the exact composition of a calculus is, before this body is extracted, and his consequent inability to determine what solvent ought to be tried

V.

VAPOUR. When a liquid is exposed to the free air, it is gradually dissipated, and this is called evaporation. — A great number of philosophers supposed that the phenomenon was occasioned by a chemical affinity of the air for water. But the experiments of Saussure, of Deluc, and of Dalton, enable us to account for these results, without having recourse to this affinity; and, consequently, there is no reason to admit it, since there is nothing in their experiments which announces its existence. A liquid introduced, whether into a vacuum or into a space filled with dry air, equally produces these vapours, of which the quantity depends absolutely on the temperature only. If the air inclosed contains already similar vapours, but in quantity less than the maximum, which accords with this temperature, the liquid introduced merely completes the quantity of vapour necessary to produce this maximum. In all this there is no difference between the air and the vacuum, but the rapidity of the evaporation, which is effected instantaneously in a vacuum, and slowly in the air, or in gases, as if the particles of these gases opposed mechanically, and by their inertia, the diffusion of the vapours.—Let us suppose a uniform temperature throughout all the extent of the atmosphere. If there be there already the whole quantity of vapour which accords with this temperature, the water of a vessel does not evaporate; but for the little which the quantity of vapour may be below this maximum, evaporation will take place, and the vessel being merely a point in comparison of the whole extent of the atmosphere, all the water which it contains will be entirely dissipated, without sensibly increasing the spring of the vapour. The quantity of vapours formerly existing have no other effect but that of relaxing more or less the evaporation, which will be so much the more rapid as the air shall formerly have been of an extreme dryness.—Let us establish now in the strata of the atmosphere an equality of some temperature; then these strata will be able to admit at the same time quantities of vapour very different, which they will, perhaps, be very far from possessing; and this inequality must sometimes maintain itself longer than the difference of temperature, because of the resistance which the air opposes to the motion and the distribution of the vapours. It will hence result, that the water will be evaporated more or less slowly in these different spaces, according as they shall be near extreme dryness. Thus the most general problem which can be proposed, in relation to evaporation, is, to determine the rapidity with which it takes place in each stratum of air, supposed infinite, when the quantity of vapour already existing in the stratum is known; and also the total quantity which can be admitted, according to the temperature. — Mr. Dalton has resolved this problem with the same sagacity which he manifested in the rest of his work on vapours. He at first sought to measure the velocity of the evaporation of the water on an atmosphere calm and dry; and he found it was proportional to the elastic force of the vapour which was formed. Accordingly, the evaporation of the same liquid is accelerated in proportion as the temperature becomes higher; and at an equal temperature it is more rapid for liquids, of which the tension is the greatest. This law of proportion is maintained, even in an atmosphere where there exists already vapours of the same nature with those which are raised; only it is necessary to calculate the velocity of the evaporation, with the difference of the elastic forces.—These results

of Mr. Dalton account for a number of phenomena which before were inexplicable. It is easily seen, for instance, why Deluc, on driving all the air from the interior of his liquid thermometers, was able to form of them water and alcohol, of which the indications were at 100°, and still higher. It is because these liquids, being in a vacuum, emit freely and instantaneously from their surface; that is to say, from the extremity of the column raised in the tube, all the quantity of vapour which the open space above them could admit; and as the vapour might be exhaled from this surface without any effort, since it spread through the vacuum, or in the vapour already existing, there was no reason then why vapour should develope itself in the interior of the liquid itself. It might then continue to be warmed and to expand, without agitation. —We have already remarked, in the article *Calorie*, that when a liquid substance passes to the state of vapour by ebullition, all the heat which is communicated to it is destroyed; and restored afresh when the vapour returns to a liquid state. Now, experiments have shewn us, that vapour is formed at every temperature, and that the temperature, being colder or warmer, changes only the degree of its elasticity. According to this analogy, we must foresee, that these will be occasioned also at every temperature, a destruction of heat when vapour is formed; and this supposition observation confirms.—In order to be certain of this it is necessary to insulate the liquid mass, upon which experiments are made, in order that it may be obliged to take from itself, if not the whole, at least the greater part of the heat which evaporation ought to take from it, which will necessarily produce a lowering of the temperature. Such is precisely the effect of the spongy vessels called *alcarazas*, and which are in use in the east for cooling water, which is intended for meals. These vessels are filled with water, and suspended in a place where there is a current of air; for instance, between two open doors. The spongy nature of the vessel permits the mass of water which it incloses, to evaporate at all points of its surface. This effect is also favoured by the current of air which carries off the vapour as fast as it is formed. Hence results an abundant evaporation, which produces a correspondent destruction of heat: but the vessel being insulated, this destruction can only be made at the expence of the water itself—a deduction taken from what the surrounding air communicates to it. Thus, the temperature sinks many degrees. A like effect may be produced by plunging the bulb of the thermometer into a wet sponge, which is then exposed to the sun; for if the degree which the thermometer, thus enveloped, shews, when placed in the shade, be observed, when it is afterwards placed in the sun, it will be seen to fall. The liquids which are evaporated the most rapidly, are those of which the evaporation produces the most sensible cold; and it is evident that this ought to be the case, since this rapidity forces them to take from themselves most heat in a given time. Thus the thermometer sinks many degrees in ether, when this liquid is evaporated.—The affinities which solids exert upon certain liquids are manifested in the vacuum, by diminishing the spring of their vapours. For instance; the water in which soda or potass has been dissolved, boils at a higher temperature than pure water. Also, the vapour of this solution necessarily possesses a less spring in the vacuum of the tube of the barometer than that of common water at the same temperature. But this diminution of spring is even made sensible in vapour already formed. When pure water has been introduced into the tube of the barometer, and its spring has been exactly ascertained, and a piece of soda be made to pass into it, which, by its lightness, only rises in the mercury, and gains the little liquid stratum in which it remains entirely plunged, the spring of the vapours seem almost immediately to decrease, and, at the end of some time, it is found reduced to a degree which corresponds with the water and soda combined. Nevertheless, there is not an atom of this soda which enters into the vapour; and the particles of vapour in the upper part of the tube are not directly in contact with it. What kind of modification

do they then experience, which can thus diminish their elastic force?

Such reflections may be made respecting all saline solutions. Almost all these boil at higher temperatures than pure water: also, at an equal temperature, the elastic force of these vapours is less than that of water. Nevertheless, in the one case, as in the other, the vapour which rises, is nothing but the vapour of the water, without a single atom of the salt. For if evaporation were carried on so as to evaporate all the liquid, the vapour might all be condensed into distilled water, and the whole weight of the salt might be found remaining behind in the solid residuum. How, then, can this watery vapour (being always the same) have at the same temperature unequal elastic forces?

It must necessarily be, that this inequality should depend on the difference of the liquid on which it reposes, and upon the unequal affinity which they exert upon it; for these are the only circumstances which are not the same, in the different cases which we examine. This leads us to look upon the different strata which compose the vapour as recumbent one upon the other, by virtue of their elasticity, until the last, which reposes immediately upon the liquid. This has necessarily for its elastic force that, with which the liquid tends to emit vapours, whatever else may be the cause which gives this tendency and this faculty. If, then, this liquid be at first pure water, and be afterwards changed in its constitution, so that its spring is diminished, then the strata of vapour which rests immediately upon its surface, or near this surface, will be more compressed by the elasticity of the superior strata, so that they shall not be supported by the spring of the liquid. They ought, then, to be precipitated into it, and it will reduce them to a liquid state also by its affinity. It will be the same with the strata, which are above the first, when they shall come in their turn to be in contact with the liquid; until, at last, the elasticity of the rarified vapour become precisely equal to the spring of the liquid; that is to say, the force with which it tends to emit vapours.

VARNISH. Lac varnishes or lacquers consist of different resins in a state of solution, of which the most common are mastich, sandarach, lac, benzoin, copal, amber, and asphaltum. The menstrua are either expressed or essential oils, also alcohol. For a lac varnish of the first kind, the common painter's varnish is to be united by gently boiling it with some more mastich, or colophony, and then diluted again with a little more oil of turpentine. The latter addition promotes both the glossy appearance and drying of the varnish. Of this sort is the amber-varnish. To make this varnish, half a pound of amber is kept over a gentle fire in a covered iron pot, in the lid of which there is a small hole, till it is observed to become soft, and to be melted together into one mass. As soon as this is perceived, the vessel is taken from off the fire, and suffered to cool a little; when a pound of good painter's varnish is added to it, and the whole suffered to boil up again over the fire, keeping it continually stirring. After this, it is again removed from the fire; and when it is become somewhat cool, a pound of oil of turpentine is to be gradually mixed with it. Should the varnish, when it is cool, happen to be yet too thick, it may be attenuated with more oil of turpentine. This varnish has always a dark brown colour, because the amber is previously half burned in this operation; but if it be required of a bright colour, amber powder must be dissolved in transparent painter's varnish, in Papin's machine, by a gentle fire. As an instance of the second sort of lac-varnishes with ethereal oils a one, may be adduced the varnish made with oil of turpentine. For making this, mastich alone is dissolved in oil of turpentine by a very gentle digesting heat, in close glass vessels. This is the varnish used for the modern transparencies employed as window blinds, fire-screens, and for other purposes. These are commonly prints, coloured on both sides, and afterwards coated with this varnish on those parts that are intended to be transparent. Sometimes fine thin calico, or Irish linen, is used for this purpose; but it requires to be primed with a solution of isinglass, before the colour is laid on. Copal may be dissolved in genuine Chio turpentine,

according to Mr. Sheldrake, by adding it in powder to the turpentine previously melted, and stirring till the whole is fused. Oil of turpentine may then be added to dilute it sufficiently. Or the copal in powder may be put into a long-necked matrass with twelve parts of oil of turpentine, and digested several days on a sand-heat, frequently shaking it. This may be diluted with one-fourth or one-fifth of alcohol. Metallic vessels or instruments, covered with two or three coats of this, and dried in an oven each time, may be washed with boiling water, or even exposed to a still greater heat, without injury to the varnish. A varnish of the consistence of thin turpentine is obtained for aërostatic machines, by the digestion of one part of elastic gum, or caoutchouc, cut into small pieces, in thirty-two parts of rectified oil of turpentine. Previously to its being used, however, it must be passed through a linen cloth in order that the undissolved parts may be left behind. The third sort of lac-varnishes consists in the spirit varnish. The most solid resins yield the most durable varnishes; but a varnish must never be expected to be harder than the resin naturally is of which it is made. Hence, it is the height of absurdity to suppose, that there are any incombustible varnishes, since there is no such thing as an incombustible resin. But the most solid resins by themselves produce brittle varnishes; therefore, something of a softer subtance must always be mixed with them, whereby this brittleness is diminished. For this purpose gum-elemi, turpentine, or balsam of copayva, are employed in proper proportions For the solution of these bodies the strongest alcohol ought to be used, which may very properly indeed be distilled over alkali, but must not have stood upon alkali. The utmost simplicity in composition with respect to the number of the ingredients in a formula is the result of the greatest skill in the art; hence it is no wonder, that the greatest part of the formulas and recipes that we meet with, are composed without any principle at all. In conformity to these rules, a fine colourless varnish may be obtained, by dissolving eight ounces of gum sandarach and two ounces of Venice turpentine in thirty-two ounces of alcohol by a gentle heat. Five ounces of shell lac and one of turpentine, dissolved in thirty-two ounces of alcohol by a very gentle heat, give a harder varnish, but of a reddish cast. To these the solution of copal is undoubtedly preferable in many respects. This is effected by triturating an ounce of powder of gum-copal, which has been dried by a gentle heat, with a drachm of camphor, and, while these are mixing together, adding by degrees four ounces of the strongest alcohol, without any digestion Between this and the gold-varnish there is only this difference, that some substances that communicate a yellow tinge are to be added to the latter. The most ancient description of two sorts of it, one of which was prepared with oil, and the other with alcohol, is to be found in Alexius Pedemontanus De i Secreti, Lucca, of which the first edition was published in the year 1557. But it is better prepared, and more durable, when made after the following prescription:—Take two ounces of shell-lac, of arnatto and turmeric, of each one ounce, and thirty grains of fine dragon's-blood, and make an extract with twenty ounces of alcohol in a gentle heat. Oil-varnishes are commonly mixed immediately with the colours, but lac or lacquer-varnishes are laid on by themselves upon a burnished coloured ground; when they are intended to be laid upon naked wood, a ground should be first given them of strong size, either alone or with some earthy colour, mixed up with it by levigation. The gold lacquer is simply rubbed over brass, tin, or silver, to give them a gold colour. Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides, in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxygen of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine. The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings. When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack •

but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry. The coloured resins or gums, such as gamboge, dragon's-blood, &c. are used to colour varnishes. To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice-stone and water; which being dried with a cloth, the work is afterward rubbed with an oiled rag and tripoli. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

VEGETABLE KINGDOM. In the mineral kingdom, little of chemical operation takes place, wherein the peculiar locality or disposition of the principles which act upon each other, appears to have considerable effect. The principles, for the most part simple, act upon each other by virtue of their respective attractions; if heat be developed, it is for the most part speedily conducted away; if elastic products be extricated, they in general make their escape,—in a word, we seldom perceive in the operations in the mineral kingdom any arrangement, which at all resembles the artificial dispositions of the chemist. But in the animal and vegetable kingdom it is far otherwise. In the former of these, bodies are regularly changed by mechanical division, by digestion, and the application of peculiar solvents, in a temperature exceeding that of the atmosphere, and the whole of the effects are assisted, modified, and kept up by an apparatus for admitting the air of the atmosphere. The subjects of the vegetable kingdom possess undoubtedly a structure less elaborate. They exhibit much less of those energies which are said to be spontaneous. The form of their vessels is much simpler, and, as far as we can perceive, their action is obedient to the changes of the atmosphere in quality and moisture, the mechanical action of winds, the temperature of the weather, and the influence of light. In these organized beings, the chemist discovers principles of a more compounded nature than any which can be obtained from the mineral kingdom. These do not previously exist in the earth, and must therefore be results of vegetable life. The most obvious difference between vegetables and animals is, that the latter are in general capable of conveying themselves from place to place; whereas vegetables, being fixed in the same place, absorb, by means of their roots and leaves, such support as is within their reach. This appears on the whole to consist of air and water. The greatest part of the support of animals are the products already elaborated in the vegetable kingdom. The products of these two kingdoms in the hands of the chemist are remarkably different, though, perhaps, not exclusively so. One of the most distinctive characters seems to be the presence of nitrogen or azotic gas, which may be extricated from animal substances by the application of nitric acid, and enters into the composition of the ammonia afforded by destructive distillation. It was long supposed, that ammonia was exclusively the product of the animal kingdom, but it is now well known that certain plants likewise afford it. When it is considered, that by far the greater part of every organized substance is capable of assuming the elastic form, and being volatilized by heat; that the products are during life brought into combination by slow and long-continued processes, and are kept separate from each other in the vessels of the plant or animal: that these combinations are liable to be altered by the destruction of these vessels, as well as by every notable change of temperature—it will not appear surprising, that the chemical analysis of plants should be in an imperfect state. See *Analysis*. In the structure of vegetables we observe the external covering or bark, the ligneous or woody matter, the vessels or tubes, and certain glandular or knotty parts. The comparative anatomy, and immediate uses of these parts, form an object of interesting research, but less immediately within the province of a chemical work. The nutrition or support of plants appears to require water, earth, light, and air. There are various experiments, which have been instituted to show, that water is the only aliment which the root draws from the earth. Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with

sheet-lead; he watered it for five years with distilled water; and at the end of that time the tree weighed one hundred and sixty-nine pounds three ounces, and the earth in which it had vegetated was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight. Messrs. Duhamel and Bonnet supported plants with moss, and fed them with mere water: they observed that the vegetation was of the most vigorous kind; and the naturalist of Geneva observes, that the flowers were more odoriferous, and the fruit of a higher flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gramineous kind, in a similar manner, with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed, that a plant, which weighed three pounds, gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water? And Braconnot has lately found mustard-seed to germinate, grow, and produce plants, that came to maturity, flowered, and ripened their seed, in litharge, flowers of sulphur, and very small unglazed shot. The last appeared least favourable to the growth of the plants, apparently because their roots could not penetrate between it so easily. All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots; but plants which require a larger quantity, have roots which extend to a great distance, and absorb humidity throughout their whole surface. The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principle which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores; and we accordingly find, that the fucus, the ulva, &c. have no roots whatever. The dung which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken of, but likewise favours the growth of the plant by that constant and steady heat, which its ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the developement of leaves and flowers in that part of a tree only, which was in the vicinity of a heap of dung. From the preceding circumstances it appears, that the influence of the earth in vegetation is almost totally confined to the conveyance of water, and probably the elastic products from putrefying substances to the plant. Vegetables cannot live without air. From the experiments of Priestley, Ingenhousz, and Sennebier, it is ascertained, that plants absorb the azotic part of the atmosphere; and this principle appears to be the cause of the fertility which arises from the use of putrefying matters in the form of manure. The carbonic acid is likewise absorbed by vegetables, when its quantity is small. If in large quantity, it is fatal to them. Chaptal has observed, that carbonic acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass, by imperceptible gradations, from an almost absolute darkness, into the light, the acid very nearly disappeared: the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed, which he ascribes to the oxygen of the same acid. Sennebier has observed, that the plants which he watered with water impregnated with carbonic acid, transpired an extraordinary quantity of oxygen, which likewise indicates a decomposition of the acid. Light is almost absolutely necessary to plants. In the dark they grow pale, languish, and die. The tendency of plants toward the light is remark-

ably seen in such vegetation as is effected in a chamber or place where the light is admitted on one side; for the plant never fails to grow in that direction. Whether the matter of light be condensed into the substance of plants, or whether it act merely as a stimulus or agent, without which the other requisite chemical processes cannot be effected, is uncertain. It is ascertained, that the processes in plants serve, like those in animals, to produce a more equable temperature, which is for the most part above that of the atmosphere. Dr. Hunter, quoted by Chaptal, observed by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap which, out of the tree, would freeze at 32 degrees, did not freeze in the tree unless the cold were augmented 15 degrees more. The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Buffon. The principles of which vegetables are composed, if we pursue their analysis as far as our means have hitherto allowed, are chiefly carbon, hydrogen, and oxygen. Nitrogen is a constituent principle of several, but for the most part in small quantity. Potash, soda, lime, magnesia, silex, alumina, sulphur, phosphorus, iron, manganese, and muriatic acid, have likewise been reckoned in the number; but *some of these occur only occasionally*, and chiefly in very small quantities; and are scarcely more entitled to be considered as belonging to them than gold, or some other substances, that have been occasionally procured from their decomposition. The following are the principal products of vegetation:—

1. Sugar. Crystallizes. Soluble in water and alcohol. Taste sweet. Soluble in nitric acid, and yields oxalic acid.

2. Sarcocoal. Does not crystallize. Soluble in water and alcohol. Taste bitter sweet. Soluble in nitric acid, and yields oxalic acid.

3. Asparagin. Crystallizes. Taste coolish and nauseous. Soluble in hot water. Insoluble in alcohol. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

4. Gum. Does not crystallize. Taste insipid. Soluble in water, and forms mucilage. Insoluble in alcohol. Precipitated by silicated potash. Soluble in nitric acid, and forms mucous and oxalic acids.

5. Ulmin. Does not crystallize. Taste insipid. Soluble in water, and does not form mucilage. Precipitated by nitric and oxymuriatic acids in the state of resin. Insoluble in alcohol.

6. Inulin. A white powder. Insoluble in cold water. Soluble in boiling water; but precipitates unaltered after the solution cools. Insoluble in alcohol. Soluble in nitric acid, and yields oxalic acid.

7. Starch. A white powder. Taste insipid. Insoluble in cold water. Soluble in hot water; opaque and glutinous. Precipitated by an infusion of nutgalls; precipitate redissolved by a heat of 120 degrees. Insoluble in alcohol. Soluble in dilute nitric acid, and precipitated by alcohol. With nitric acid yields oxalic acid and a waxy matter.

8. Indigo. A blue powder. Taste insipid. Insoluble in water, alcohol, ether. Soluble in sulphuric acid. Soluble in nitric acid, and converted into bitter principle and artificial tannin.

9. Gluten. Forms a ductile elastic mass with water. Partially soluble in water; precipitated by infusion of nutgalls and oxygenized muriatic acid. Soluble in acetic acid and muriatic acid. *Insoluble in alcohol.* By fermentation becomes viscid and adhesive, and then assumes the properties of cheese. Soluble in nitric acid, and yields oxalic acid.

10. Albumen. Soluble in cold water. Coagulated by heat, and becomes insoluble. Insoluble in alcohol. Precipitated by infusion of nutgalls. Soluble in nitric acid. Soon putrefies.

11. Fibrin. Tasteless. Insoluble in water and alcohol. Soluble in diluted alkalies, and in nitric acid. Soon putrefies.

12. Gelatin. Insipid. Soluble in

water. Does not coagulate when heated. Precipitated by infusion of galls.

13. Bitter principle. Colour yellow or brown. Taste bitter. Equally soluble in water and alcohol. Soluble in nitric acid. Precipitated by nitrate of silver.

14. Extractive. Soluble in water and alcohol. Insoluble in ether. Precipitated by oxygenized muriatic acid, muriate of tin, and muriate of alumina; but not by gelatin. Dyes fawn colour.

15. Tannin. Taste astringent. Soluble in water and in alcohol of 0·810. Precipitated by gelatin, muriate of alumina, and muriate of tin.

16. Fixed oils. No smell. Insoluble in water and alcohol. Forms soaps with alkalies. Coagulated by earthy and metallic salts.

17. Wax. Insoluble in water. Soluble in alcohol, ether, and oils. Forms soap with alkalies. Fusible.

18. Volatile oil. Strong smell. Insoluble in water. Soluble in alcohol. Liquid. Volatile. Oily. By nitric acid inflamed, and converted into resinous substances.

19. Camphor. Strong odour. Crystallizes. Very little soluble in water. Soluble in alcohol, oils, acids. Insoluble in alkalies. Burns with a clear flame, and volatilizes before melting.

20. Birdlime. Viscid. Taste insipid. Insoluble in water. Partially soluble in alcohol. Very soluble in ether. Solution green.

21. Resins. Solid. Melt when heated. Insoluble in water. Soluble in alcohol, ether, and alkalies. Soluble in acetic acid. By nitric acid converted into artificial tannin.

22. Guaiacum. Possesses the characters of resins; but dissolves in nitric acid, and yields oxalic acid and no tannin.

23. Balsams. Possess the characters of the resins, but have a strong smell; when heated, benzoic acid sublimes. It sublimes also when they are dissolved in sulphuric acid. By nitric acid converted into artificial tannin.

24. Caoutchouc. Very elastic. Insoluble in water and alcohol. When steeped in ether reduced to a pulp, which adheres to every thing. Fusible, and remains liquid. Very combustible.

25. Gum resins. Form milky solutions with water, transparent with alcohol. Soluble in alkalies. With nitric acid converted into tannin. Strong smell. Brittle, opaque, infusible.

26. Cotton. Composed of fibres Tasteless. Very combustible. Insoluble in water, alcohol, and ether. Soluble in alkalies. Yields oxalic acid to nitric acid.

27. Suber. Burns bright, and swells. Converted by nitric acid into suberic acid and wax. Partially soluble in water and alcohol.

28. Wood. Composed of fibres. Tasteless. Insoluble in water and alcohol. Soluble in weak alkaline lixivium. Precipitated by acids. Leaves much charcoal when distilled in a red heat. Soluble in nitric acid, and yields oxalic acid.

VEGETATION (Saline) M. Chaptal has given us a good memoir on this subject, in the Journal de Physique, for October 178[illegible], entitled Observations on the Influence of the Air and Light upon the Vegetation of Salts. In the operations in the large way, of his manufactory of medical and chemical products, he often observed that salts, particularly the metallic, vegetated on the side most exposed to the light, and the frequency of the effect induced him to make some direct experiments on the subject. For this purpose he took several capsules of glass, and covered the half of each, as well above as below, with black silk. At the same time, he prepared solutions of almost all the earthy, alkaline, or metallic compound salts in distilled water, at the temperature of the atmosphere. These capsules were placed on tables in a well closed chamber, which had no chimney, and of which the doors and windows were carefully stopped up, in order that the evaporation might not be hastened by any agitation of the air. Reflected light, by which we understand the light from the clouds, was admitted through a small aperture in one of the window-shutters. By this management, as well as the disposition of the capsules, one-half of each of their respective cavities received light from the aperture, and the other was almost perfectly in darkness. The solutions were then carefully poured into the

capsules by means of a funnel resting on the middle of the bottom, so that the border of the fluid was neat and uniform, without any irregularity or drop of the fluid falling on the bare surface of the glass. Upwards of two hundred experiments were made with variations of the principal trials, so as to leave no doubt with regard to the constancy of the results. The most remarkable fact is, that the vegetation took place on those surfaces only which were illuminated. This phenomenon was so striking in most of the solutions, that in the space of a few days, and frequently even within one single day, the salt was elevated lines above the liquor upon the enlightened surface, while there did not appear the smallest crust or edge on the dark part. Nothing could be more interesting, than to observe this vegetation, projecting frequently more than an inch, and marking the line of distinction between the illuminated and dark parts of the vessel. The sulphates of iron, of zinc, and other metals, more especially presented this appearance. It was generally observed, that the vegetation was strongest toward the most enlightened part. This phenomenon may be rendered still more interesting, by directing the vegetation at pleasure towards the different parts of the vessel. For this purpose nothing more is required than to cover the several parts in succession. For the vegetation always takes place in the enlightened parts, and quickly ceases in that which is covered. When the same solution has stood for several days, the insensible evaporation gradually depresses its surface, and a crust or edge of salt is left in the obscure part. But the salt never rises, or at least very imperfectly, above the liquor, and cannot be compared with the true vegetation. When salts are suffered to vegetate in this manner, the spontaneous evaporation of the fluid affords very few crystals. All the saline matter extends itself on the sides of the vessel.

VEINS. Metallic veins are often separated from the rocks they intersect, by a thin wall or lining of mineral substances distinct from the rock, and sometimes also by a layer of clay on each side of the vein. The same substance which forms the outer coat of the vein is also frequently intermixt with the ore, or forms layers alternating with it; this is called the matrix, gangue, or vein-stone. It appears as if the ore and the vein-stone had been deposited over each other, on the sides of the vein, at different times, till they met and filled up the fissure. Sometimes the ore extends in a compact mass from one side of the vein to the other. Not unfrequently there are hollow spaces in veins, called druses, which are lined with crystals. In these cavities the most beautiful and regular crystalline forms are obtained. Metallic veins often divide and unite again, and sometimes they separate into a number of smaller branches, called strings. To what depth metallic veins descend is not known, nor is it ascertained whether they generally grow wider or narrower in their descent. The opinions of miners on this subject are so various, it may fairly be inferred that they differ in this respect in different situations. Veins are seldom rich in ore near the surface, but increase in richness as they descend, and, at greater depths, become poorer again. When Pryce wrote the Mineralogy of Cornwall, it was believed that the richest state of a mine of copper in that county was from 80 to 100 yards deep, and for tin from 40 to 120 yards. This account by no means agrees with the present state of the Cornish mines. Copper and tin are procured in considerable quantities at the depth of 400 yards in the Dolcoath mine. The Ecton copper mine in Staffordshire is now worked at the depth of 472 yards: it is the deepest mine in England. The deepest mine that has been worked in Europe, or in any part of the world, is one at Truttenberg in Bohemia, which is 1000 yards below the surface. Metallic veins frequently contain different ores at various depths. Iron ore, copper ore, cobalt ore, and silver ore succeed each other in some of the mines in Saxony. In France there are mines which contain copper ore in the lowest part, silver ore above, and over that, iron ore. The thickness of veins and the quantity and quality of the ore they contain, vary in every mine. Some veins are only a few inches wide; others are several feet, and some-

times several yards in width. Veins are often narrow in one part, and swell out in another. The vein at the Dolcoath Mine in Cornwall, varies from two or three feet to forty feet, and in some places it contracts to little more than six inches. The vein stone is quartz, in which are imbedded masses called bunches of copper pyrites, consisting of copper united with sulphur. Veins sometimes descend in a direction parallel with the beds of rock in which they occur, and swell into large cavities which contract again to a narrow string, often so small that the ore appears lost; but by pursuing the indications of the vein, it is again found to enlarge: these are called pipe veins. The blue john or fluor spar mine near Castleton is of this kind. The vein which contains this spar is separated from the limestone rock by a lining of cawk or sulphat of barytes, and by a thin layer of unctuous clay; it swells out into large cavities which contract again and entirely exclude the ore, leaving nothing but the lining of the vein to conduct the miner to another repository of the spar. The crystallizations and mineral incrustations on the roof and sides of the natural caverns which are passed through in this mine, far exceed in beauty those of any other cavern in England; and were the descriptions of the grotto of Antiparos translated into the simple language of truth, there is reason to believe it would be found inferior in magnificence and splendour of mineral decoration to the natural cavern in the fluor mine. This mine is rarely visited by travellers; the descent is safe, but the roof being low in some parts, it is rather difficult of access. One metallic vein often crosses or cuts through another: in such instances, it is evident that the vein which is cut through must be more antient than that which intersects it. This observation respecting the relative ages of veins was first made by Mr. Pryce in his Mineralogia Cornubiensis. When a vein runs parallel with the beds or strata of a mountain, it forms a bed or stratum which some geologists consider as a repository of metallic ores distinct from veins. Iron, which is universally disseminated through the mineral kingdom, most commonly occurs in beds forming an original part of rocks. Whether other metallic beds are veins which have taken the same direction with the seams of the rock, or constitute a distinct formation, may be doubtful. Some dykes, and perhaps some metallic veins, appear to be contemporaneous with the rocks they intersect. Sometimes the quality of the rock changes as it approaches a vein or dyke; thus granite has been observed to become smaller grained in the vicinity of veins. The substance of a vein or dyke is occasionally intermixt with that of the rock, and the parts appear fused together and sometimes graduate into each other. These instances are favourable to the opinion that the substance of the vein and rock were once in a melted state, and separated during the consolidation of the mass. Such veins form a part of the original constitution of the rock. Other veins are evidently posterior, as they have fractured and dislocated the rocks through which they pass. The direction of veins is not very regular. In England they generally run nearly east and west, and north-east and south-west; but have frequently undulations and deviations from a straight line: the most powerful veins are more regular in their course than smaller ones. Where two veins in the same district have the same direction, or run parallel, it is observed that their contents are similar; but where they run in different directions, the contents vary. Molina, in his interesting History of Chili, mentions a vein of silver at Uspalata, in the Andes, which is nine feet in thickness throughout its whole extent, and has been traced ninety miles. Smaller veins branch off from each side of it, and penetrate the neighbouring mountains to the distance of thirty miles. It is believed that this vein stretches to the distance of 300 miles. A vein called the Tideswell Rake, in Derbyshire, extends some miles east and west; it is worked from the surface, and may be seen near the road side between Great Hucklow and Tideswell. It is lost at its two extremities by the lime rock which it intersects dipping under other rocks; but in the opinion of miners who have worked in North Wales, the same

vein rises again in the lime rocks of that district. Particular metallic ores are peculiar to certain rocks; thus, tin stone occurs in granite and some kinds of slate, but has never been found in lime-stone. Certain ores are also associated together; thus, lead and zinc almost always occur in the same vein, but in different proportions. Metals are rarely found in a native state, except platina, gold, silver, and copper. They are usually combined with some substance by which they are mineralized, which is either oxygen, sulphur, or an acid; sometimes they are combined with other metals, and form alloys. Different combinations of the same metal exist in one vein. Native copper, sulphuret of copper, carbonate of copper, or malachite, sulphat of copper, or blue vitriol, and copper combined with lead and iron, frequently occur together in the same mine. Galena, a sulphuret of lead, is often associated with white lead ore, or carbonate of lead. The latter, though a rich ore containing seventy per cent. of lead, has no metallic appearance, and was mistaken for cawk and thrown away by the miners in Derbyshire until the year 1803 or 1804. The mines of that county have been worked since the time of the emperor Adrian, and the quantity of ore which has been wasted during that period must have been immense. In what manner metallic veins were filled with ore has greatly divided the opinions of geologists. Dr. Hutton supposes that both dykes and veins were filled with their contents in a state of fusion by injection from below, the expansive force of the melted matter having cracked the surface and opened a passage for its reception. That many dykes were so formed appears probable from circumstances previously stated. Other dykes appear to have been open fissures filled by materials washed from the surface, and contain rounded stones and sometimes undecayed vegetable matter. From a dyke of clay in a coal mine in Yorkshire, 215 feet deep, were drawn out long vegetable fibres, apparently roots; the woody part of which was unchanged, and burned like the roots of common woods. Werner supposes all veins and dykes were first produced by the shrinking of the materials of which mountains are composed; and that metallic veins have been filled from above by the ores in a state of solution. This theory has been advanced with much confidence, and warmly supported by many geologists; but we have no hesitation in asserting that it is demonstratively repugnant to facts: indeed, the implicit credit which has been given to Mr. Werner's dogmas on this subject, is one among numerous instances of men of distinguished talents resigning their judgment to authority, and supporting the most absurd propositions, when conformable to their favourite hypothesis. If veins were filled by metallic solutions from above, these solutions must have covered the highest mountains over the whole earth; and instead of finding metallic ores in the present confined repositories, they would fill all the cavities and valleys in every part of the world. As this theory supposes likewise that veins were formed at different times, a number of these metallic solutions would succeed each other, and we should find regular strata of ore in all primary and transition rocks; and the quantity formed by these deep seas of metallic matter would be inconceivably great. This theory is decidedly invalidated by the following facts. When a metallic vein passes through different kinds of rock, it is generally observed that the quality of the ore varies with that of the rock through which it passes; and even different beds of the same rock are more productive than others, and are called by miners, bearing measures. This is the case in Durham, in Derbyshire, and probably in every part of England and Wales. Mr. Werner quotes one instance, as if it were extraordinary, of the quality and quantity of the ore being changed by the nature of the rock which it intersects, and is inclined to admit that elective affinity for the rock may have contributed to the effect. The circumstance, so far from being extraordinary, is of common occurrence, and known to all working miners. The entire cessation of the ore in one part of a rock, and its re-appearance below, are still more striking. In Derbyshire the beds of metalliferous limestone are separated by beds of basaltic rock

called toad-stone. When a vein of lead is worked through the first limestone down to the toad-stone, it ceases to contain any ore, and often entirely disappears: on sinking through the toad-stone to the second limestone, the ore is found again, but is cut off by a lower bed of toad-stone, under which it appears again in the third lime-stone. In strong veins particles of lead occur in the toad-stone, but in very small quantities. If mineral veins were filled from above by metallic solutions, it is impossible to conceive that the nature of the rock should change the quality of the ore; much less could the ore disappear in one stratum, and appear again in a stratum below it. Nor could the vein be filled with melted matter ejected from below: for in either case it would be equally impossible to explain why the ore is separated by the toad-stone, though the vein is continued through it. Mr. Farey, whose account of the Derbyshire mines is well deserving attention, says that where the beds of lime-stone are divided by seams of clay, these seams frequently cut off the vein as effectually as the thick beds of toad-stone. Such facts prove, incontestably, that veins were not filled with their contents from above. If metallic matter was not poured in from above, or ejected from below, in what manner did it come into the vein? The state of chemical science, and the facts at present known, are too limited to furnish a solution to this interesting question. There are, however, certain indications which may serve as a clue to future discovery. The variation of the mineral products in veins as they pass through different strata, seems to prove that the strata were efficient causes in producing this variation. Perhaps metallic matter was diffused through different rocks according to their elective affinity, and separated from them by voltaic electricity, the different sides of the vein possessing different states of electricity; or the strata may act like a series of plates in the voltaic pile, separating and secreting metallic matter from its different combinations. Some of the metals and other substances found in veins are capable of solution in hydrogen gas, and perhaps all of them may be so by natural processes; in this state they may have penetrated the vein and deposited their contents. The discovery, however, of the metallic nature of the very earths of which rocks are composed, and the probability that the metals are compound substances, of which hydrogen forms a part, open to our view the possibility of the formation of metallic matter by natural processes, which it may not be beyond the powers of the human mind to develope, if not to imitate. If metallic matter be now forming in mines, the process of its formation is extremely slow; but there are circumstances which appear to prove that it may, in some instances, be perceived. Mr. Trebra, director of the mines in Hanover, has seen a leather thong, suspended from the roof of a mine, coated with silver ore: he has also observed native silver and vitreous silver ore coating the wooden supports left in mines two hundred years before. He is led from these circumstances to support the opinion that metallic ores were formed by mineral vapours or exhalations, or were once in a gaseous state. Our present acquaintance with facts is too limited to decide the interesting question respecting the formation of metallic ores, and it is more consonant with the true spirit of philosophy frankly to confess our ignorance than to form systems from imperfect data. The veins of coal bear a great resemblance to metallic veins. For farther illustration, we subjoin a description by Mr. Bakewell, in the Transactions of the Geological Society, of a coal field at Bradford near Manchester, which we have already referred to in our article on coal; and to which article we again call our readers attention. This field is of very limited dimensions, extending little more than two miles in length, and 2000 yards in breadth. The greatest depth to which the workings have been carried, is 140 yards. Ten seams of coal rise to the surface, some of which are greatly deteriorated by an intermixture of pyrites. The river Medlock flows nearly at right angles with the line of bearing of strata and a section is exposed on its banks to a considerable distance. The strata, which alternates with beds of coal, are the same that are usually found

under similar circumstances in Lancashire, Cheshire, and the west of Derbyshire; viz. argillaceous and bituminous shale with vegetable impressions, and iron stone, sometimes in beds, sometimes in nodules. These occur over the first coal limestone of a reddish-brown colour. The field is bounded by red silicious sandstone similar to that on which the town of Manchester stands, and 15 or 16 yards of its contact with that rock, the coal is soft and hardly worth working. The coal measures dip to the south at an angle of about 30°, and wherever they have been proved on the southern side of the field abuts against the sand stone, but on the northern side, at the distance of ten yards from the red rock, a bed of coal, four feet in thickness, rises to the surface perpendicularly, and terminates the coal measures: the space between this bed and the red rock being filled with broken stones and rubble without any appearance of stratification. This perpendicular bed has been wrought to the depth of 40 feet, and is of the same quality and general appearance as a four-feet bed which rises near the middle of the field. There is a dyke in one part of the field filled with a stone nearly similar to the red rock, but it does not affect the strata on either side of it. Fourteen hundred yards to the north of the Bradford coal field, and separated from it by red sandstone, is the coal field of Droylsden. The first coal that rises there, is at the distance of sixty yards from the red rock, and similar to the bed which rises at the distance of 350 yards from the perpendicular coal in the Bradford field. *A A* represents the length of the field. *B B* represents its breadth. *C C C C* different beds of coals which rise to the surface. *P P* the perpendicular bed of coal. *L L* the limestone. *R R R* the red sand rock. *S S* two beds of coal 20 inches thick, one of them in the Droylsden coal field. The next plate represents the section of the same strata on a plane perpendicular to *A A*. It is probable that the strata in both these fields, were once united, and have been separated by some convulsion of nature, in consequence of which the red rock has been interposed like a wedge between them; a sliding motion being given to the strata by lateral pressure; for a force acting in a direct line from above or beneath could not produce the bending or folding of the four feet coal.

VERATRIA. A new vegetable alkali, discovered lately by MM. Pelletier and Caventou, in the veratrum sabatilla, or cevadilla, and some other plants. The seeds of cevadilla, after being freed from an unctuous and acid matter by ether, were digested in boiling alcohol. As this infusion cooled, a little wax was deposited; and the liquid being evaporated to an extract, re-dissolved in water, and again concentrated by evaporation, parted with its colouring matter. Acetate of lead was now poured into the solution. The excess of lead was thrown down by sulphuretted hydrogen, and liquor being concentrated by evaporation, was treated with magnesia, and again filtered. The precipitate, boiled in alcohol, gave a solution, which, on evaporation, left a pulverulent matter, extremely bitter, and with decidedly alkaline characters. The precipitate by the acetate of lead, gave, on examination, gallic acid; and hence it is concluded that the new alkali existed in this seed as a gallate. Veratria is white, pulverulent, has no odour, but excites violent sneezing. It is very acrid, but not bitter. It produces violent vomiting in very small doses, a few grains may cause death. It is very little soluble in water. It is very soluble in alcohol, and rather less soluble in ether. It fuses at 122° Fah. On cooling, it becomes an amber-coloured translucent mass. It acts on test papers like an alkali, and forms salts uncrystallizable by evaporation. The salts appear like a gum. The supersulphate only seems to present crystals. Iodine and chlorine produce, with veratria, an iodate, hydriodate, chloride, and muriate.

VERDIGRIS. A crude acetate of copper.

VERDITER, is a blue pigment, obtained by adding chalk or whiting to the solution of copper in aquafortis. Dr. Merret says, that it is prepared in the following manner: A quantity of whiting is put into a tub, and upon this the solution of the copper is poured. The mixture is to be stirred

every day for some hours together, till the liquor loses its colour. The liquor is then to be poured off, and more solution of copper is to be added. This is to be repeated till the whiting has acquired the proper colour. Then it is to be spread on large pieces of chalk, and dried in the sun. It appears from M. Pelletier's analysis, that 100 grains of the very best verditer contain, of carbonic acid 30, of water 3½, of pure lime 7, of oxygen 9¾, and of pure copper 50. The author remarks, that the verditers of inferior quality contain more chalk and less copper.

VERJUICE. A kind of harsh, austere vinegar, made of the expressed juice of the wild apple, or crab. The French give this name to unripe grapes, and to the sour liquor obtained from them.

VERMILION. The red sulphuret of mercury or Cinnabar.

VESUVIAN. Idocrase of Haüy; a sub-species of pyramidal garnet. Glistening vitreo-resinous. Translucent. Refracts double. Scratches felspar. Brittle. Sp. gr. 3·3 to 3·4. It becomes electrical by friction. Its constituents are, silica 35·5, lime 33, alumina 22·25, oxide of iron 7·5, oxide of manganese 0·25, loss 1·5. It occurs in considerable abundance in unaltered ejected rocks, in the vicinity of Vesuvius. At Naples it is cut into ring-stones.

VINEGAR, is the acetic acid diluted, and in the form in which it is found in commerce. There are four varieties.

1. Wine vinegar.
2. Malt vinegar.
3. Sugar vinegar.
4. Wood vinegar.

Wine vinegar is, of course, made only in wine countries. At Paris, the wine destined for vinegar is mixed with wine lees, and the whole being transferred to sackcloths, the liquid matter is forced out by pressure, received in casks, which are set upright, with a small aperture at the top, and exposed to the heat of the sun in summer, of a stove in winter. Fermentation soon comes on; and in the case of regulating this fermentation, by taking care that the heat is not too great or too small, lies the difficulty of making vinegar. In a fortnight in summer or in double that time in winter, the fermentation is finished; the vinegar is put into casks, with chips of birch wood, and in a fortnight is fit for use. At Orleans they prefer wine of a year old for making vinegar. It is there much of the vinegar used in France is made. The used casks called mothers are never emptied more than half, and are successively filled again, to acetify new portions of wine. Alcohol added to the fermenting liquor increases the quantity of vinegar. In this country, vinegar is often made from malt. The essential ingredient is saccharine matter; and therefore wine, malt liquor, sugar, or any other substance containing saccharine matter, will, by fermentation, yield vinegar. The wort, after 36 hours, is put into casks, which are laid on their sides, with their bung-holes loosely covered, and exposed to the sun in summer, or to the heat of a stove-room in winter. In three months the vinegar is fit for the manufacture of sugar of lead. In domestic purposes the process is different. The liquor is put into casks having a false cover pierced with holes, fixed at about a foot from the bottom. On this a considerable quantity of the refuse from British wine manufacturers, or cheap raisins, is placed. The liquor is turned into another barrel every twenty-four hours, in which time it has begun to become warm. Sometimes the whole is fermented as above. Good vinegar is also made from weak syrup of sugar, at the rate of 18 oz. to every gallon of water. The principle is the same. Good vinegar has been made from the refuse of bee-hives. Wood vinegar and its uses we have noticed at length in the article *Pyroligneous Acid*.

VINEGAR OF SATURN. Solution of acetate of lead.

VINEGAR, (RADICAL.) Acetic acid.

VITAL AIR.—See *Oxygen*.

VITRIFICATION.—See *Glass*, also *Silica*.

VITRIOLIC ACID.—See *Sulphuric Acid*.

VOLATILE ALKALI.—See *Ammonia*.

VOLATILITY. The property of bodies, by which they are disposed to assume the vaporous or elastic state, and quit the vessels in which they are placed.

VOLCANOES, are openings made in the earth's surface by internal fires; they regularly, or at intervals, throw out smoke, vapour, flame, large stones, sand, and melted stone, called lava. Some volcanoes throw out torrents of mud and boiling water. Volcanoes generally exist in the vicinity of the sea or large lakes, and also break out from unfathomable depths below the sea, and form new islands with the melted lava and stones which they eject. When a volcano breaks out in a new situation, it forms a vast rent or fissure, through which lava and stones are thrown out, that soon choke up the passage, and confine the eruption to one or more openings, round which a conical mountain is formed, the open part of which is called the crater. The indications of an approaching eruption are an increase of smoke from the summit, which sometimes rises to a vast height, branching in the form of a pine-tree. Tremendous explosions, like the firing of artillery, commence after the increase of smoke, and are succeeded by red-coloured flames and showers of stones; at length the lava flows out from the top of the crater, or breaks through the sides of the mountain, and covers the neighbouring plains with melted matter, which becoming consolidated, forms a stony mass often not less than some hundred square miles in extent, and several yards in thickness. The eruption has been known to continue several months. The quantity of volcanic powder, called ashes, thrown out, is inconceivably great. During one eruption of Ætna, a space of 150 miles in circuit was covered with a stratum of sand twelve feet thick. When the lava flows freely, the earthquakes and explosions become less violent; which proves that they were occasioned by the confinement of the erupted matter both gaseous and solid. The smoke and vapour of volcanoes are highly electrical. The long period of repose which sometimes takes place between two eruptions of the same volcano, is particularly remarkable. From the building of Rome to the 79th year of the Christian era, no mention is made of Vesuvius, though it had evidently been in a prior state of activity, as Herculaneum and Pompeii, which were destroyed by the eruption of that year, are paved with lava. From the 12th to the 16th century, it remained quiet for nearly 400 years, and the crater was overgrown with lofty trees. It was descended by Bracchini, an Italian writer, a little time prior to the great eruption of 1631; the bottom was at that time a vast plain surrounded by caverns and grottoes. Ætna has continued burning since the time of the poet Pindar, with occasional intervals of repose seldom exceeding 30 or 40 years. Submarine volcanoes are preceded by a violent boiling and agitation of the water, and by the discharge of volumes of gas and vapour, which take fire and roll in sheets of flame over the surface of the waves. Masses of rock are darted through the water with great violence, and accumulate till they form new islands. Sometimes the crater of the volcano rises out of the sea during an eruption. In 1783, a submarine volcano broke out near Iceland, which formed a new island; it raged with great fury for several months. The island afterwards sunk, leaving only a reef of rocks. In December, 1720, a violent earthquake was felt at Tercera, one of the Azores: the next morning a new island nine miles in circumference was seen, from the centre of which rose a column of smoke; it afterwards sunk to a level with the sea. Near the little island of Santori, in the Grecian archipelago, submarine volcanoes have repeatedly burst forth during the last 2000 years and formed several new islands: three of the ancient eruptions are recorded by Pliny, Strabo, and Seneca. The last eruption was in the year 1767. The number of volcanoes has been estimated at near 200; but they may be supposed greatly to exceed this estimate, if we consider those volcanoes as only dormant, and not extinct, which still present indications of subterranean heat. In the Azores there are no less than forty-two active or dormant volcanoes; almost all the islands in the Atlantic, and many in the Pacific ocean and the Indian Seas are volcanic. A range of active and dormant volcanoes extends from the southern extremity of America to the arctic circle. Numerous volcanoes exist in Iceland; and the hot

sulphurous exhalations from craters in various parts of Italy prove that their internal fires are not extinguished. Of the volcanoes in northern Asia, or the interior of Africa, we have little information, and the volcanoes covered by the sea cannot be estimated; but from the above statement we are authorized in believing that volcanic fires are more extensively operative on the surface of the globe than many geologists are disposed to admit. Their source is deep under the surface of the earth, and many circumstances indicate that a connection exists between volcanoes at a vast distance from each other. In 1783, when the submarine volcano near Iceland suddenly ceased, a volcano broke out 200 miles distant, in the interior of the island, and at the same time the great earthquakes took place in Calabria. On the night in which Lima and Callao were destroyed by an earthquake, four new volcanoes broke out in the Andes. Other instances of the apparent connection of earthquakes with distant volcanoes have been before stated. Were the source of volcanic fires near the surface, the country in their vicinity would sink down; and it is impossible to conceive how the same volcano could continue its eruptions incessantly for more than 2000 years, which is the case with Stromboli, situated in the Lipari islands. Fragments of rocks, such as lime and gypsum, are thrown out of volcanoes unchanged by fire, which proves that the source of heat was deep below the range of these rocks; they have been merely driven up by the subterranean explosion, which forced a passage through them. From the various phenomena which volcanoes present, we may with probability infer that the internal part of our planet is in an igneous state, however difficult it may be to explain in what manner this heat is generated and confined. In every department of nature, our inquiries are terminated by ultimate facts, beyond which further research becomes vain. The constant generation and emission of light from the surface of the sun is more inexplicable and surprising than the constant generation of heat in the centre of the planets; but we cannot refuse our assent to the fact, though it is far beyond the power of the human mind to conceive by what means the particles of light are propelled through space with such astonishing velocity. We are too apt to measure natural operations by their coincidence with the received system of philosophy, and to make our own ignorance the standard of truth. Had all the volcanoes in the world been dormant for the last 2000 years, and were we only acquainted with their existence by the writings of ancient historians, we should discredit the fact, and prove its impossibility by an appeal to established chemical principles; we should further accompany the proof with a pathetic lamentation over the credulity of former times.—The descent of stones from the atmosphere was denied during a longer period, though the fact is now established beyond all doubt: this should teach us to be less confident in our own knowledge, for there are still remaining "more things in heaven and earth than are dreamed of in our philosophy."—Admitting the existence of central fire in the earth, it is not difficult to conceive that there may be determinate causes by which its intensity is increased or diminished at certain periods. We know little respecting the operation of electric or voltaic energy in the laboratory of nature; but from the existence of electric light at the poles we may infer that electric currents are passing through the ducts which are found in the craters of volcanoes.—Sulphureous and sulphuric acids are formed by the combustion of sulphur during eruptions: these act upon lavas and rocks, and produce different combinations, of which the most important are alum, sulphate of magnesia, gypsum, and green copperas. Hydrogen and sulphuretted hydrogen are emitted from volcanoes in vast quantities. Whether phosphorus be a product of volcanoes is unknown: its extreme inflammability prevents it from being discovered in a concrete form; but the dense white clouds, resembling bales of cotton, which sometimes cover Vesuvius, resemble the fumes produced by the combustion of phosphorus. Among the products of volcanoes we find only three substances which are combustible in the atmosphere, sulphur, hydrogen, and a small

portion of carbon; but it has been conjectured by sir H. Davy that the earths and alkalies, which form lavas, exist in the centre of the globe in a metallic state, and take fire by the access of water. This property of the newly-discovered metals, to inflame instantly on the access of water, by which they are converted into earths or alkalies, offers an easy explanation of the origin of volcanic fires, could we suppose that substances so extremely inflammable and oxydable have remained for ages in a metallic state. There may, however, be processes in the vast laboratory of the globe that constantly separate the earths from oxygen, and prepare them for the support of volcanic fires, by which they are thrown upon the surface, and a connection is established between the internal and external parts of the planet. The force with which all volcanic products are thrown is astonishing. In the year 1769, a stone twelve feet high and four in circumference, was thrown to the distance of a quarter of a mile from the crater; and in the year 1771, sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling. This indicates an elevation of near two thousand feet. The eruption of volcanoes is frequently aqueous; the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water mixed with lava destroyed Portici and Torre del Greco. Sir W. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites. Some eruptions are of a muddy substance; and these form the tufa and the puzzolano. The eruption which buried Herculaneum is of this kind. Sir W. Hamilton found an antique head, the impression of which was well enough preserved to answer the purpose of a mould. Herculaneum at the least depth is seventy feet under the surface of the ground, and in many places one hundred and twenty. The puzzolano is of various colours. It is usually reddish, sometimes grey, white, or green. It frequently consists of pumice-stone in powder, but sometimes it is formed of oxided clay. One hundred parts of red puzzolano afforded Bergmann, silex 55, alumina 20, lime 5, iron 20. When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways, &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited; it is in these hollow places that the sal ammoniac, the muriate of soda, and other substances sublime. A lava may be turned out of its course by opposing banks or dykes against it; this was done in 1669, to save Catania; and Sir William Hamilton proposed it to the king of Naples to preserve Portici. The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking in some places. Lava is sometimes swelled up and porous. The lightest is called pumice-stone. The substances thrown out by volcanoes are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, felspar, mica, shells, schorl, &c. The fire of volcanoes is seldom strong enough to vitrify the matters it throws out. We know only of the yellowish capillary and flexible glass thrown out by the volcanoes of the island of Bourbon, on the 14th of May, 1766, (M. Commerson,) and the lapis gallinaceus ejected by Hecla. Mr. Egolfrigouson, who is employed by the observatory at Copenhagen, has settled in Iceland, where he used a mirror of a telescope, which he had made out of the black agate of Iceland. The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been everywhere volcanized. Chaptal observed several ancient volcanoes at present cultivated; and the line which separates the other earth from the volcanic earth, constitutes the limit of vegetation. The ground over the ruins

of Pompeia, is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface. The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since in some instances it appears to have required nearly two thousand years before lava was fit to receive the plough. In this respect, however, lavas differ very widely, so that our reasoning from them must at best be very vague. An argument has been drawn from this phenomenon to prove the antiquity of the globe: but the silence of the most ancient authors concerning the volcanoes of the kingdom of France, of which we find such frequent traces, indicates that these volcanoes have been extinguished from time immemorial,—a circumstance which carries their existence to a very distant period. Beside this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Ætna; nevertheless, these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when we observe that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth. The height of Vesuvius above the level of the sea is 3659 feet; its circumference 34,442. The height of Ætna is 10,036 feet, and its circumference 180,000. The various volcanic products are applicable to several uses.

1. The puzzolano is of admirable use for building in the water; when mixed with lime it speedily fixes itself, and water does not soften it, for it becomes continually harder and harder. Chaptal has proved that oxided ochres afford the same advantage for this purpose; they are made into balls and baked in a potter's furnace in the usual manner. The experiments made at Sette by the commissary of the province, prove, that they may be substituted with the greatest advantage, instead of the puzzolano of Italy.

2. Lava is likewise susceptible of vitrification; and in this state it may be blown into opaque bottles of the greatest lightness, which Chaptal says he has done at Krepian and at Alais. The very hard lava, mixed in equal parts with wood-ashes and soda, produced, he says, an excellent green glass. The bottles made of it were only half the weight of common bottles, and much stronger, as was proved by Chaptal's experiments, and those which M. Joly de Fleury ordered to be made under his administration.

3. Pumice-stone likewise has its uses; it is more especially used to polish most bodies which are somewhat hard. It is employed in the mass or in powder, according to the intended purpose. Sometimes, after levigation, it is mixed with water to render it softer.

Besides the convulsions of nature displayed in volcanoes already noticed, other operations are carried on below the fathomless depths of the sea, the nature of which can only be conjectured by the effects produced. Nor is it more astonishing that inflammable substances should be found beneath the bottom of the sea, than at similar depths on land, and that there also the impetuous force of fire should cause the imprisoned air and elastic gases to expand; and, by its mighty force, should drive the earth at the bottom of the sea above its surface. These marine volcanoes are perhaps more frequent, though they do not so often come within the reach of human observation, than those on land; and stupendous must be the operations carried on, when matter is thrown up to an extent which the ingenuity of man does not enable him to reach by fathoming. Many instances have occurred, as well in ancient as in modern times, of islands having been formed in the midst of the sea; and their sudden appearance has constantly been preceded by violent agitations of the surrounding waters, accompanied by dreadful noises, and in some instances by fiery eruptions from the newly-formed isles, which are composed of various substances, frequently intermixed with a considerable quantity of volcanic lava. Such islands remain for ages barren, but in a long course of time become

abundantly fruitful. It is a matter of curious inquiry, whether springs are found on such newly created spots, when the convulsions which gave them birth have subsided: but on this point it would seem that we are not possessed of any certain information, as it does not appear that they have been visited by any naturalist with the express view of recording their properties. Among the writers of antiquity who have transmitted accounts of islands which have thus started up to the view of the astonished spectator, Seneca asserts, that in his time, the island of Therasea, in the Egean sea, was seen to rise in this manner, by several mariners who were sailing near the point of its ascent. Pliny's relation is still more extraordinary; for he says, that in the Mediterranean, thirteen islands emerged at once from the sea, the cause of which he ascribes rather to the retiring of the waters, than to any subterraneous operation of nature; but he speaks at the same time of the island of Hiera, in the vicinity of Therasea, as having been formed by subterraneous explosions, and enumerates several others said to have been derived from a similar origin; on one of which, he says, a great abundance of fishes were found, of which, however, all who ate perished soon after. It is to the Grecian Archipelago and the Azores that we are to look for the grandest and most surprising instances of this phenomenon. We will select an example from each of these groupes of islands, beginning with the former. Before we enter, however, on the somewhat minute details we shall have to bring forward, on this very curious and interesting subject, it may not be improper to observe, that the island of Acroteri, of great celebrity in ancient history, appears to have its surface composed of pumice-stone, encrusted by a surface of fertile earth; and that it is represented by the ancients as having risen, during a violent earthquake, from the sea. Four neighbouring islands are described as having had a similar origin, notwithstanding the sea is in that part of the Archipelago of such a depth as to be unfathomable by any sounding-line. These arose at different times: the first, long before the commencement of the Christian era; the second in the first century; the third in the eighth; and the fourth in 1573. To proceed to a phenomenon of a similar nature, belonging to the same cluster of islands, which being of a more recent date, we are enabled to enter into all its particulars. They are such as cannot fail to interest and surprise. On the 22d of May, 1707, a severe earthquake was felt at Stanchio, an island of the Archipelago; and on the ensuing morning, a party of seamen, discovering not far off what they believed to be a wreck, rapidly rowed towards it; but finding rocks and earth instead of the remains of a ship, hastened back, and spread the news of what they had seen in Santorini, another of these islands. However great the apprehensions of the inhabitants were at the first sight, their surprise soon abated, and in a few days, seeing no appearance of fire or smoke, some of them ventured to land on the new island. Their curiosity led them from rock to rock, where they found a kind of white stone, which yielded to the knife like bread, and nearly resembled that substance in colour and consistence. They also found many oysters sticking to the rocks; but while they were employed in collecting them, the island moved and shook under their feet, on which they ran with precipitation to their boats. Amid these motions and tremblings the island increased, not only in height, but in length and breadth; still, occasionally, while it was raised and extended on the one side, it sunk and diminished on the other. The person to whom we are indebted for this narrative, observed a rock to rise out of the sea, forty or fifty paces from the island, which, having been thus visible for four days, sunk, and appeared no more: several others appeared and disappeared alternately, till at length they remained fixed and unmoved. In the mean time the colour of the surrounding sea was changed: at first it was of a light green, then reddish, and afterwards of a pale yellow, accompanied by a noisome stench, which spread itself over a part of the island of Santorini. On the 16th of July smoke first appeared, not indeed on the island, but issuing from a ridge of black stones

which suddenly rose about sixty paces from it, where the depth of the sea was unfathomable. Thus there were two separate islands, one called the White, and the other the Black Island, from the different appearances they exhibited. This thick smoke was of a whitish colour, like that of a lime-kiln, and was carried by the wind to Santorini, where it penetrated the houses of the inhabitants. In the night between the 19th and 20th of July, flames began to issue with the smoke, to the great terror of the inhabitants of Santorini, especially of those occupying the castle of Scaro, who were distant about a mile and a half only from the burning island, which now increased very fast, large rocks daily springing up, which sometimes added to its length, and sometimes to its breadth. The smoke also increased, and there not being any wind, ascended so high as to be seen at Candia, and other distant islands. During the night, it resembled a column of fire, fifteen, or twenty feet in height; and the sea was then covered with a scurf or froth, in some places reddish, and in others yellowish, from which proceeded such a stench that the inhabitants throughout the whole island of Santorini burnt perfumes in their houses, and made fires in the streets, to prevent infection. This, indeed, did not last above a day or two, for a strong gale of wind dispersed the froth, but drove the smoke on the vineyards of Santorini, by which the grapes were, in one night, parched up and destroyed. This smoke also caused violent head-ache, attended with retchings. On the 31st of July the sea smoked and bubbled in two different places near the island, where the water formed a perfect circle, and looked like oil when beginning to simmer. This continued above a month, during which time many fishes were found dead on the shore of Santorini. On the following night a dull hollow noise was heard, like the distant report of several cannon, which was instantly followed by flames of fire, shooting up to a great height in the air, where they suddenly disappeared. The next day the same hollow sound was several times heard, and succeeded by a blackish smoke, which, notwithstanding a fresh gale blew at the time, rose up to a prodigious height, in the form of a column, and would probably, in the night, have appeared as if on fire. On the 7th of August a different noise was heard, resembling that of large stones thrown, at very short intervals, into a deep well. This noise, having lasted for some days, was succeeded by another much louder, so nearly resembling thunder, as scarcely to be distinguished from three or four real claps, which were heard at the same time. On the 21st the fire and smoke were very considerably diminished; but the next morning they broke out with still greater fury than before. The smoke was red, and very thick, the heat at the same time being so intense, that all around the island the sea smoked and bubbled surprisingly. At night, by the means of a telescope, sixty small openings or funnels, all emitting a very bright flame, were discovered on the highest part of the island, conjointly resembling a large furnace; and on the other side of the great volcano there appeared to be as many. On the morning of the 23d, the island was much higher than on the preceding day, and its breadth increased by a chain of rocks which had sprung up in the night nearly fifty feet above the water. The sea was also again covered with reddish froth, which always appeared when the island seemed to have received any considerable additions, and occasioned an intolerable stench, until it was dispersed by the wind and the motion of the waves. On the 5th of September, the fire opened another vent at the extremity of the Black Island, from which it issued for several days. During that time little was discharged from the large furnace; but from this new passage the astonished spectator beheld the fire dart up three several times to a vast height, resembling so many prodigious sky-rockets of a glowing lively red. The following night the sub-aqueous fire made a terrible noise, and immediately after a thousand sheaves of fire darted into the air, where breaking and dispersing, they fell like a shower of stars on the island, which appeared in a blaze, presenting to the amazed spectator at once a most dreadful and beautiful illumination. To these natural fireworks, succeeded a kind of meteor, which for some time hung over the

castle of Scaro, and which, having a resemblance to a flaming sword, served to increase the consternation of the inhabitants of Santorini. On the 9th of September, the White and Black Islands united; after which the western end of the island grew daily in bulk. There were now four openings only which emitted flames: these issued forth with great impetuosity, sometimes attended with a noise like that of a large organ-pipe, and sometimes like the howling of wild beasts. On the 12th the subterraneous noise was much augmented, having never been so frequent or so dreadful as on that and the following day. The bursts of this subterraneous thunder, like a general discharge of the artillery of an army, were repeated ten or twelve times within twenty-four hours, and immediately after each clap, the large furnace threw up huge red-hot stones, which fell into the sea at a great distance. These claps were always followed by a thick smoke, which spread clouds of ashes over the sea and the neighbouring islands. On the 18th of September an earthquake was felt at Santorini. It did but little damage, although it considerably enlarged the burning island, and in several places gave vent to the fire and smoke. The claps were also more terrible than ever; and in the midst of a thick smoke, which appeared like a mountain, large pieces of rock, which afterwards fell on the island, or into the sea, were thrown up with as much noise and force as balls from the mouth of a cannon. One of the small neighbouring islands was covered with these fiery stones, which being thinly crusted over with sulphur, gave a bright light, and continued burning until that was consumed. On the 21st, a dreadful clap of subterraneous thunder was followed by very powerful lightnings, and at the same instant the new island was so violently shaken, that part of the great furnace fell down, and huge burning rocks were thrown to the distance of two miles and upwards. This seemed to be the last effort of the volcano, and appeared to have exhausted the combustible matter, as all was quiet for several days after: but on the 25th, the fire broke out again with still greater fury, and among the claps, one was so terrible, that the churches of Santorini were soon filled with crowds of people, expecting every moment to be their last; and the castle and town of Scaro suffered such a shock, that the doors and windows of the houses flew open. The volcano continued to rage during the remaining part of the year; and in the month of January, 1708, the large furnace, without one day's intermission, threw out stones and flames, at least once or twice, but generally five or six times a day. On the 10th of February, in the morning, a pretty strong earthquake was felt at Santorini, which the inhabitants considered as a prelude to greater commotions in the burning island; nor were they deceived, for soon after the fire and smoke issued in prodigious quantities. The thunder-like claps were redoubled, and all was horror and confusion: rocks of an amazing size were raised up to a great height above the water; and the sea raged and boiled to such a degree as to occasion great consternation. The subterraneous bellowings were heard without intermission, and sometimes in less than a quarter of an hour, there were six or seven eruptions from the large furnace. The noise of the repeated claps, the quantity of huge stones which flew about on every side, the houses at Santorini tottering to their very foundations, and the fire, which now appeared in open day, surpassed all that had hitherto happened, and formed a scene terrific and astonishing beyond description. The 15th of April was rendered memorable by the number and violence of the bellowings and eruptions, by one of which, nearly a hundred stones were thrown at the same instant into the air, and fell again into the sea at about two miles distant. From that day, until the 22nd of May, which may be considered as the anniversary of the birth of the new island, things continued much in the same state, but afterwards the fire and smoke subsided by degrees, and the subterraneous thunders became less terrible. On the 15th of July, 1709, the bishop of Santorini, accompanied by several friars, hired a boat, to take a near view of the island. They made directly towards it, on that side where the sea did not bubble, but where it smoked

very much. Being within the range of this vapour, they felt a close suffocating heat, and found the water very hot; on which they directed their course towards a part of the island at the farthest distance from the large furnace. The fires, which still continued to burn, and the boiling of the sea, obliged them to make a great circuit, notwithstanding which, they felt the air about them very hot and sultry. Having encompassed the island, and surveyed it carefully from an adjacent one, they judged it to be two hundred feet above the sea, about a mile broad, and five miles in circumference; but not being thoroughly satisfied, they resolved to make an attempt at landing, and accordingly rowed towards that part of the island where they perceived neither fire nor smoke. When, however, they had proceeded to within the distance of a hundred yards, the great furnace discharged itself with its usual fury, and the wind blew upon them so dense a smoke, and so heavy a shower of ashes, that they were obliged to abandon their design. Having retired somewhat further, they let down their sounding lead, with a line ninety-five fathoms in length, but it was too short to reach the bottom. On their return to Santorini, they observed that the heat of the water had melted the greater part of the pitch employed in caulking their boat, which had now become very leaky. From that time until the 15th of August, the fire, smoke, and noises continued, but not in so great a degree; and it appears that for several years after the island still increased, but that the fire and subterraneous noises were much abated. The most recent account we have been enabled to collect, is that of a late traveller, who, in 1811, passed this island at some distance. It appeared to him like a stupendous mass of rock, but was not inhabited or cultivated. It had then long ceased to burn. We have stated that similar eruptions of islands have occurred in the groupe of the Azores. Thus, in December, 1720, a violent earthquake was felt on the island of Tercera. On the following morning a new island, which had sprung up in the night, made its appearance, and ejected a huge column of smoke. The pilot of a ship, who attempted to approach it, sounded on one of these newly-formed islands, with a line of sixty fathoms, but could not find a bottom. On the opposite side, the sea was deeply tinged with various colours, white, blue, and green, and was very shallow. This island was larger on its first appearance than at some distance of time afterwards; it at length sunk beneath the level of the sea, and is now no longer visible. "What can be more surprising," observes the author of the preceding account, "than to see fire, not only force its way out of the bowels of the earth, but likewise make for itself a passage through the waters of the sea! What can be more extraordinary, or foreign to our common notions of things, than to observe the bottom of the sea rise up into a mountain above its surface, and become so firm an island as to be able to resist the violence of the greatest storms! I know that subterraneous fires, when pent up in a narrow passage, are able to elevate a mass of earth as large as an island; but that this should be done in so regular and precise a manner, that the water of the sea should not be able to penetrate and extinguish those fires; and that, after they should have exhausted themselves, the mass of earth should not fall down, or sink again with its own weight, but still remain in a manner suspended over the great arch below—this seems to me more surprising than any of the facts which have been related of Mount Etna, Vesuvius, or any other volcano." In the first part of the Transactions of the Royal Society for the year 1812, captain Tillard, of the British navy, has published his very interesting narrative of a similar phenomenon, which occurred in the same sea near the Azores. We give this narrative in his own words.

"Approaching the island of St. Michael's, on Sunday the 12th of June, 1811, in his majesty's sloop Sabrina, under my command, we occasionally observed, rising in the horizon, two or three columns of smoke, such as would have been occasioned by an action between two ships, to which cause we universally attributed its origin. This opinion was, however, in a very short time changed, from the smoke increasing and ascending

in much larger bodies than could possibly have been produced by such an event; and, having heard an account, prior to our sailing from Lisbon, that in the preceding January or February a volcano had burst out within the sea near St. Michael's, we immediately concluded that the smoke we saw proceeded from that cause, and, on our anchoring the next morning in the road of Ponta del Gada, we found this conjecture correct as to the cause, but not as to the time; the eruption of January having totally subsided, and the present one having only burst forth two days prior to our approach, and about three miles distant from the one before alluded to.—Desirous of examining as minutely as possible a contention so extraordinary between two such powerful elements, I set off from the city of Ponta del Gada on the morning of the 14th, in company with Mr. Read, the Consul-general of the Azores, and two other gentlemen. After riding about twenty miles across the north-west end of the island of St. Michael's, we came to the edge of a cliff, whence the volcano burst suddenly upon our view in the most terrific and awful grandeur. It was only a short mile from the base of the cliff, which was nearly perpendicular, and formed the margin of the sea,—this cliff being (as nearly as I could judge) from three to four hundred feet high. To give you an adequate idea of the scene by description, is far beyond my powers · but, for your satisfaction, I shall attempt it. Imagine an immense body of smoke rising from the sea, the surface of which was marked by the silvery rippling of the waves, occasioned by the light and steady breezes incidental to those climates in summer. In a quiescent state, it had the appearance of a circular cloud revolving on the water like an horizontal wheel, in various and irregular involutions, expanding itself gradually on the lee side, when suddenly a column of the blackest cinders, ashes, and stones would shoot up in the form of a spire, at an angle of from ten to twenty degrees from a perpendicular line, the angle of inclination being universally to windward; this was rapidly succeeded by a second, third, and fourth shower, each acquiring greater velocity, and overtopping the other, till they had attained an altitude as much above the level of our eye, as the sea was below it. As the impetus with which the columns were severally propelled diminished, and their ascending motion had nearly ceased, they broke into various branches resembling a groupe of pines! these again forming themselves into festoons of white feathery smoke, in the most fanciful manner imaginable, intermixed with the finest particles of falling ashes, which at one time assumed the appearance of innumerable plumes of black and white ostrich feathers surmounting each other; at another, that of the light wavy branches of a weeping willow. During these bursts, the most vivid flashes of lightning continually issued from the densest part of the volcano; and the cloud of smoke, now ascending to an altitude much above the highest point to which the ashes were projected, rolled off in large masses of fleecy clouds, gradually expanding themselves before the wind in a direction nearly horizontal, and drawing up to them a quantity of water-spouts, which formed a most beautiful and striking addition to the general appearance of the scene. That part of the sea where the volcano was situated, was upwards of thirty fathoms deep, and at the time of our viewing it the volcano was only four days old. Soon after our arrival on the cliff, a peasant observed he could discern a peak above the water: we looked, but could not see it: however, in less than half an hour, it was plainly visible, and before we quitted the place (which was about three hours from the time of our arrival) a complete crater was formed above the water, not less than twenty feet high on the side where the greatest quantity of ashes fell; the diameter of the crater being apparently about four or five hundred feet. The great eruptions were generally attended with a noise like the continued firing of cannon and musquetry intermixed, as also with slight shocks of earthquakes; several of which having been felt by my companions, but none by myself, I had become half sceptical, and thought their opinion arose merely from the force of imagination, but while we were sitting within five or six yards of the edge of the cliff, par-

taking of a slight repast which had been brought with us, and were all busily engaged, one of the most magnificent bursts took place which we had yet witnessed, accompanied by a very severe shock of an earthquake. The instantaneous and involuntary movement of each was to spring upon his feet; and I said, "This admits of no doubt." The words had scarcely passed my lips, before we observed a large portion of the face of the cliff, about fifty yards on our left, falling, which it did with a violent crash. So soon as our first consternation had a little subsided, we removed about ten or a dozen yards further from the edge of the cliff, and finished our dinner. On the succeeding day, June 15th, having the Consul and some other friends on board, I weighed, and proceeded with the ship towards the volcano, with the intention of witnessing a night view; but in this expectation we were greatly disappointed, from the wind freshening, and the weather becoming thick and hazy, and also from the volcano itself being clearly more quiescent than it was the preceding day. It seldom emitted any lightning, but occasionally as much flame as may be seen to issue from the top of a glass-house or foundry chimney. On passing directly under the great cloud of smoke, about three or four miles distant from the volcano, the decks of the ship were covered with fine black ashes, which fell intermixed with small rain. We returned the next morning, and late on the evening of the same day I took my leave of St. Michael's, to complete my cruize. On opening the volcano clear of the north-west part of the island, after dark on the 16th, we witnessed one or two eruptions that, had the ship been near enough, ould have been awfully grand. It appeared one continued blaze of lightning; but its distance from the ship, upwards of twenty miles, prevented our seeing it with effect. Returning again towards St. Michael's, on the 4th of July, I was obliged, by the state of the wind, to pass with the ship very close to the island, which was now completely formed by the volcano, being nearly the height of Matlock High Tor, about eighty yards above the sea. At this time it was perfectly tranquil; which circumstance determined me to land, and explore it more narrowly. I left the ship in one of the boats, accompanied by some of the officers. As we approached, we perceived that it was still smoking in many parts, and, upon our reaching the island, found the surf on the beach very high. Rowing round to the lee side, with some little difficulty, by the aid of an oar, as a pole, I jumped on shore, and was followed by the other officers. We found a narrow beach of black ashes, from which the side of the island rose in general too steep to admit of our ascending; and where we could have clambered up, the mass of matter was much too hot to allow our proceeding more than a few yards in the ascent. The declivity below the surface of the sea was equally steep, having seven fathoms water at scarcely the boat's length from the shore, and at the distance of twenty or thirty yards we sounded twenty-five fathoms. From walking round it in about twelve minutes, I should judge that it was something less than a mile in circumference; but the most extraordinary part was the crater, the mouth of which, on the side facing St. Michael's, was nearly level with the sea. It was filled with water, at that time boiling, and was emptying itself into the sea by a small stream about six yards over, and by which I should suppose it was continually filled again at high water. This stream, close to the edge of the sea, was so hot, as only to admit the finger to be dipped suddenly in, and taken out again immediately. It appeared evident, by the formation of this part of the island, that the sea had, during the eruptions, broken into the crater in two places, as the east side of the small stream was bounded by a precipice; a cliff between twenty and thirty feet high, forming a peninsula of about the same dimension in width, and from fifty to sixty feet long, connected with the other part of the island by a narrow ridge of cinders and lava, as an isthmus, of from forty to fifty feet in length, from which the crater rose in the form of an amphi theatre. This cliff, at two or three miles distance from the island, had the appearance of a work of art resembling a small fort or block-house. The top of this we were determined,

if possible, to attain; but the difficulty we had to encounter in doing so was considerable; the only way to attempt it was up the side of the isthmus, which was so steep, that the only mode by which we could effect it, was by fixing the end of an oar at the base, with the assistance of which we forced ourselves up in nearly a backward direction. Having reached the summit of the isthmus, we found another difficulty; for it was impossible to walk upon it, as the descent on the other side was immediate, and as steep as the one we had ascended; but, by throwing our legs across it, as would be done on the ridge of a house, and moving ourselves forward by our hands, we at length reached that part of it where it gradually widened itself, and formed the summit of the cliff, which we found to have a perfectly flat surface, of the dimensions before stated. Judging this to be the most conspicuous situation, we here planted the union, and left a bottle sealed up, containing a short account of the origin of the island, and of our having landed upon it, and naming it Sabrina Island. Within the crater I found the complete skeleton of a guard-fish, the bones of which, being perfectly burnt, fell to pieces upon attempting to take them up; and by the account of the inhabitants on the coast of St. Michael's, great numbers of fish had been destroyed during the early part of the eruption, as large quantities, probably suffocated or poisoned, were occasionally found drifted into the small inlets or bays. The island, like other volcanic productions, is composed principally of porous substances, generally burned to complete cinders, with occasional masses of a stone, which I should suppose to be a mixture of iron and limestone.—Sabrina Island has gradually disappeared since the month of October, 1811, leaving an extensive shoal. Smoke was discovered still issuing out of the sea in the month of February, 1812, near the spot where this wonderful phenomenon appeared."

VULCANIC THEORY OF THE EARTH. This theory, also called Plutonic, in opposition to the Neptunian Theory (which supposes all matter to have formerly been dissolved in a fluid, and to have gradually been deposited in the forms in which we now find it,) supposes, that, formerly the world was in a fluid state, by the power of heat; on the abatement of which rocks became solid; and that the inequalities of surface of hills and mountains have been caused by the force of internal fire elevating them above the common level. It assumes that, at great depths in the mineral regions, an immense heat is constantly present, and that this heat operates in the fusion and the consolidation of the substances deposited. To the action of this heat, the formation of all our strata is attributed. They are conceived to be the wrecks of a former world, which have been more or less perfectly fused by this agent, and by subsequent cooling have been consolidated. The subterraneous fire being placed at immense depths, the substances on which it operates must be under a vast pressure. This prevents their volatilization in whole or in part, and from this circumstance it explains appearances, in minerals and qualities, which they possess, which would otherwise appear inconsistent with the supposition of their being formed by fire.—Dr. Hutton conceives, that in this globe there is a constant system of decay and renovation, and that the processes by which they are effected have an uniform relation to each other. The solid matter is wasted by the powers which operate upon it. The hardest rocks are worn down by air and water—causes, which, however slowly they may operate, are constant in their action, and which, therefore, in indefinite time, must be equal to the production of the greatest effects. From the figure of the surface of the earth the decayed materials must be carried towards the ocean, and ultimately deposited in its bed. From this theory are explained the appearances which our strata present in their structure and their position. In regard of structure, there is a great variety; some, as granite, are composed chiefly of substances in a crystallized state, and these are supposed to have been completely fused; others, as sandstone and chalk, are heterogeneous in their texture, or imperfectly consoli-

dated; and these are supposed to have been only in a softened state, and between these there exist many intermediate degrees. As to position, some are horizontal, some inclined, others vertical, irregular, and abrupt; and such appearances must have arisen from the operation of that power by which they were raised. In their first formation at the bottom of the ocean, their arrangement must have been horizontal; but in their elevation, by an expansive power acting from beneath, their constituents must have been broken, and every variety of position produced.—This theory has its most zealous partisans as well as the Neptunian theory, and its leading champion was the late Dr. Hutton. If it be admitted that fusion by fire, and solution in water, are the only ways by which the fluidity of the matter of which the rocks and strata could have been formed by crystallization, the supporter of the Huttonian theory will be entitled to assume, like the Wernerian, that, if he can show insurmountable objections to the theory of his opponent, he has established his point. But the more indifferent and impartial will not be easily satisfied, and finding it impossible to ascribe many phenomenon solely to the action of water or of fire, will not decide in favour of either, but will be inclined to believe both agents must have had their share in the production of present appearances, and will not be hurried into the attempt of forming a system where as yet the materials are so imperfect.—The existence of such a strong degree of heat, as to fuse the masses of granite, or other primitive mountains, is asserted by the Wernerians to be impossible; and, certainly, it is not easy to show it to be probable. As we see it is very difficult to fuse by the strongest heat which we can produce even the minutest particles: and whence, then, it may be asked, was there such a heat as to fuse the immense strata and ranges of mountains, which, from their connexion, it appears, were formed at one time?—How, also, can such heat be supported in the central parts of the earth?—On exploring many parts of the world, the intense action of fire becomes very apparent, and little doubt can remain of its having been the cause of the formation of innumerable mineral substances. Not only in the neighbourhood of active volcanoes do we find the marks of fire, but we find similar products extending over a vast tract of country. Thus, over a great part of Italy are found volcanic products, and strata of lava of immense extent. In countries where no volcanoes now exist, and where none are recorded to have existed in the memory of man, there are equally visible marks of fire. Many of the substances supposed to have been formed by fire, the Neptunians attempt to account for by other means, as in the cases of basalt, but the igneous origin of this substance seems to be satisfactorily made out. That immense subterraneous fires still exist is clear from the numerous volcanoes in all parts of the world, which rage with boundless force, and which seem, in some cases, to have communication with each other. The power of fire in elevating immense strata is evidenced in the formation of new islands, by volcanoes in the ocean, as well as by the elevation of the hill of Monte-novo, near Naples, in one night, which now occupies the principal part of the site of the ancient Lucrine lake. To such queries it is not easy to give a very satisfactory answer. It may, nevertheless, be said, that we are but very imperfectly acquainted with the nature of heat, and the means by which it may be maintained; also, that the effects produced on bodies subjected to the immense pressure which this theory supposes, cannot be estimated by what we see under very different circumstances. This, however, does but in a very small degree obviate the objection, and it will still recur upon the mind, that, from the vast extent of the strata, and the extreme infusibility of the matter of which they are composed, the heat requisite must exceed not only any which we know, but even that which the imagination can conceive; and that for the production of such a heat no adequate cause can be assigned. If a reference be made to particular minerals, there will be often great difficulties in believing them to have been formed by heat, and this is most strikingly the case where there are organic remains of animal and vege-

table matter, which must have been destroyed by a degree of heat sufficient to fuse such masses of rock.

In short, although we must acknowledge ourselves convinced that heat has often operated to a great extent in particular districts, we cannot readily be satisfied that it is an agent by which, on a grand scale, the present arrangement and constitution of the globe have been produce

W.

WACKE. A mineral substance between clay and basalt. It is sometimes simple; but when it inclines to basalt it contains hornblende and mica. Colour greenish-grey; opaque; streak shining; *soft*; easily frangible; specific gravity 2·55 to 2·9; fuses like basalt; it seldom contains petrifactions.

WADD. This name is given to plumbago, or black lead.

WADD BLACK. An ore of manganese found in Derbyshire. It is remarkable for the property of taking fire when mixed with linseed oil.

WASH. The technical term for the fermented liquor, of whatever kind, from which spirit is intended to be distilled.—See *Alcohol and Distillation*.

WATER. It is scarcely necessary to give any definition or description of this universally known fluid. It is a very transparent fluid, possessing a moderate degree of activity with regard to organized substances, which renders it friendly to animal and vegetable life, for both which it is indeed indispensably necessary. Hence it acts but slightly on the organs of sense, and is therefore said to have neither taste nor smell. It appears to possess considerable elasticity, and yields in a perceptible degree to the pressure of air in the condensing machine, as Canton proved, by inclosing it in an open glass vessel with a narrow neck. The solubility or insolubility of bodies in this fluid composes a large part of the science of chemistry.—See *Salt*. Water is not only the common measure of specific gravities, but the tables of these may be usefully employed in the admeasurement of irregular solids: for one cubic foot is very nearly equal to 1000 ounces avoirdupois. The numbers of the table denoting the specific gravities, do therefore denote likewise the number of ounces avoirdupois in a cubic foot of each substance. Native water is seldom if ever found perfectly pure. The waters that flow within or upon the surface of the earth, contain various earthy, saline, metallic, vegetable, or animal particles, according to the substances over or through which they pass. Rain and snow waters are much purer than these, although they also contain whatever floats in the air, or has been exhaled along with the watery vapours. The purity of water may be known by the following marks or properties of pure water:—

1. Pure water is lighter than water that is not pure.
2. Pure water is more fluid than water that is not pure.
3. It has no colour, smell or taste.
4. It wets more easily than the waters containing metallic and earthy salts, called hard waters, and feels softer when touched.
5. Soap, or a solution of soap in alcohol, mixes easily and perfectly with it.
6. It is not rendered turbid by adding to it a solution of gold in aqua regia, or a solution of silver, or of lead, or of mercury, in nitric acid, or a solution of acetate of lead in water.

For the habitudes of water with saline matter, see *Salt*, and the different substances. Water was, till modern times, considered as an elementary or simple substance. Previous to the month of October 1776, the celebrated Macquer, assisted by M. Sigaud de la Fond, made an experiment by burning hydrogen gas in a bottle, without explosion, and holding a white china saucer over the flame. His intention appears to have been that of ascertaining whether any fuliginous smoke was produced, and he observes, that the saucer remained perfectly clean and white, but was moistened with perceptible drops of a clear fluid resembling water, and

which, in fact, appeared to him and his assistant to be nothing but pure water. He does not say whether any test was applied to ascertain this purity, neither does he make any remark on the fact. In the month of September 1777, Messrs. Bucquet and Lavoisier not being acquainted with the fact, which is incidentally and concisely mentioned by Macquer, made an experiment to discover what is produced by the combustion of hydrogen. They fired five or six pints of hydrogen in an open and wide-mouthed bottle, and instantly poured two ounces of lime-water through the flame, agitating the bottle during the time the combustion lasted. The result of this experiment shewed, that carbonic acid was not produced. Before the month of April 1781, Mr. John Warltire, encouraged by Dr. Priestley, fired a mixture of common air and hydrogen gas in a close copper vessel, and found its weight diminished. Dr. Priestley, likewise, before the same period, fired a like mixture of hydrogen and oxygen gas in a closed glass vessel, Mr. Warltire being present. The inside of the vessel, though clean and dry before, became dewy, and was lined with a sooty substance. These experiments were afterwards repeated by Mr. Cavendish and Dr. Priestley, and it was found that the diminution of weight did not take place, neither was the sooty matter perceived. These circumstances, therefore, must have arisen from some imperfection in the apparatus or materials with which the former experiments were made. It was in the summer of the year 1781 that Mr. Henry Cavendish was busied in examining what becomes of the air lost by combustion, and made those valuable experiments which were read before the Royal Society on the 15th of January, 1784. He burned 500,000 grain measures of hydrogen gas with about two and a half times the quantity of common air, and by causing the burned air to pass through a glass tube eight feet in length, 135 grains of pure water were condensed. He also exploded a mixture of 19,500 grain measures of oxygen gas, and 37,000 of hydrogen, in a close vessel. The condensed liquor was found to contain a small portion of nitric acid, when the mixture of the air was such that the burned air still contained a considerable portion of oxygen. In this case it may be presumed that some of the oxygen combines with a portion of nitrogen present. In the mean time, M. Lavoisier continued his researches; and during the winter of 1781-1782, together with M. Gingembre, he filled a bottle of six pints with hydrogen, which being fired, and two ounces of lime-water poured in, was instantly stopped with a cork, through which a flexible tube communicating with a vessel of oxygen was passed. The inflammation ceased, except at the orifice of the tube, through which the oxygen was pressed, where a beautiful flame appeared. The combustion continued a considerable time, during which the lime-water was agitated in the bottle. Neither this, nor the same experiment repeated with pure water, and with a weak solution of alkali instead of lime-water, afforded the information sought after, for these substances were not at all altered. The inference of Mr. Warltire respecting the moisture on the inside of the glass, in which Dr. Priestley first fired hydrogen and common air was, that these airs, by combustion, deposited the moisture they contained. Mr. Watt, however, inferred from these experiments, that water is a compound of the burned airs, which have given out their latent heat by combustion, and communicated his sentiments to Dr. Priestley, in a letter dated April 26, 1783. It does not appear that the composition of water was known or admitted in France, till the summer of 1783, when M. Lavoisier and M. de la Place, on the 24th of June repeated the experiment of burning hydrogen and oxygen in a glass vessel over mercury, in a still greater quantity than had been burned by Mr. Cavendish. The result was nearly five gros of pure water. M. Monge made a similar experiment at Paris, nearly at the same time, or perhaps before. This assiduous and accurate philosopher then proceeded, in conjunction with M. Meusnier, to pass the steam of water through a red hot iron tube, and found that the iron was oxidized, and hydrogen disengaged; and the steam of water being passed over a variety of other combustible or oxidable substances, produced similar re-

sults, the water disappearing, and hydrogen being disengaged. These capital experiments were accounted for by M. Lavoisier, by supposing the water to be decomposed into its component parts, oxygen and hydrogen, the former of which unites with the ignited substance, while the latter is disengaged. The grand experiment of the composition of water by Fourcroy, Vauquelin, and Seguin, was begun on Wednesday, May 13, 1790, and was finished on Friday, the 22d of the same month. The combustion was kept up 185 hours with little interruption, during which time the machine was not quitted for a moment. The experimenters alternately refreshed themselves when fatigued, by lying for a few hours on mattrasses in the laboratory. To obtain the hydrogen, 1) Zinc was melted and rubbed into a powder in a very hot mortar. 2. This metal was dissolved in concentrated sulphuric acid diluted with seven parts of water. The air procured was made to pass through caustic alkali. To obtain the oxygen, two pounds and a half of crystallized hyperoxymuriate of potash were distilled, and the air was transferred through caustic alkali. The volume of hydrogen employed was 25963·568 cubic inches, and the weight was 1039·358 grains. The volume of oxygen was 12570·942, and the weight was 6209·869 grains. The total weight of both elastic fluids was 7249·227. The weight of water obtained was 7244 grains, or 12 ounces, 4 gros, 45 grains. The weight of water which should have been obtained was 12 ounces, 4 gros, 49·227 grains. The deficit was 4·227 grains. The quantity of azotic air before the experiment was 415·256 cubic inches, and at the close of it 467. The excess after the experiment was consequently 51·744 cubic inches. This augmentation is to be attributed, the academicians think, to the small quantity of atmospheric air in the cylinders of the gasometers, at the time the other airs were introduced. These additional 51 cubic inches could not arise from the hydrogen, for experiment shewed that it contained no azotic air. Some addition of this last fluid, the experimenters think, cannot be avoided, on account of the construction of the machine. The water being examined, was found to be as pure as distilled water. Its specific gravity to distilled water was as 18871 : 18670. The decomposition of water is elegantly effected by electricity. The composition of water is demonstrated by exploding two volumes of hydrogen and one of oxygen, in the eudiometer. They disappear totally, and pure water results.

WATERING LAND, or IRRIGATION, is a practice which at first view appears the reverse of torrefaction; and in general, in nature, the operation of water is to bring earthy substances into an extreme state of division. But in the artificial watering of meadows, the beneficial effects depend upon many different causes, some chemical, some mechanical. Water is absolutely essential to vegetation; and when land has been covered by water in the winter, or in the beginning of spring, the moisture that has penetrated deep into the soil, and even the subsoil, becomes a source of nourishment to the roots of the plant in the summer, and prevents those bad effects that often happen in lands in their natural state, from a long continuance of dry weather. When the water used in irrigation has flowed over a calcareous country, it is generally found impregnated with carbonate of lime; and in this state it tends, in many instances, to ameliorate the soil. Common river water also generally contains a certain portion of organizable matter, which is much greater after rains than at other times, and which exists in the largest quantity when the stream rises in a cultivated country. Even in cases when the water used for flooding is pure, and free from animal or vegetable substances, it acts by causing the more equable diffusion of nutritive matter existing in the land, and in very cold seasons it preserves the tender roots and leaves of the grass from being affected by frost. Water is of greater specific gravity at 42° Fahrenheit than at 32°, the freezing point; and hence, in a meadow irrigated in winter, the water immediately in contact with the grass is rarely below 40°, a degree of temperature not at all prejudicial to the living organs of plants. In 1804, in the month of March, sir H. Davy examined the temperature in a water

meadow near Hungerford, in Berkshire, by a very delicate thermometer. The temperature of the air at seven in the morning was 29°. The water was frozen above the grass. The temperature of the soil below the water in which the roots of the grass were fixed, was 43°. In general those waters which breed the best fish are the best fitted for watering meadows; but most of the benefits of irrigation may be derived from any kind of water. It is, however, a general principle, that waters containing ferruginous impregnations, though possessed of fertilizing effects, when applied to a calcareous soil, are injurious on soils that do not effervesce with acids; and that calcareous waters, which are known by the earthy deposit they afford when boiled, are of most use on silicious soils, or other soils containing no remarkable quantity of carbonate of lime.

WATER OF CRYSTALLIZATION. Many salts require a certain proportion of water to enable them to retain the crystalline form, and this is called their water of crystallization. Some retain this so feebly, that it flies off on exposure to the air, and they fall to powder. These are the efflorescent salts. Others have so great an affinity for water, that their crystals attract more from the air, in which they dissolve. These are the deliquescent.

WATERS (MINERAL). The examination of mineral waters, with a view to ascertain their ingredients, and thence their medical qualities, and the means of compounding them artificially, is an object of considerable importance to society. It is likewise a subject which deserves to be attended to, because it affords no mean opportunity for the agreeable practice of chemical skill. But this investigation is more especially of importance to the daily purposes of life, and the success of manufactures. It cannot but be an interesting object to ascertain the component parts and qualities of the waters daily consumed by the inhabitants of large towns and vicinities. A very minute portion of unwholesome matter, daily taken, may constitute the principal cause of the differences in salubrity which are observable in different places. And with regard to manufactures, it is well known to the brewer, the paper-maker, the bleacher, and a variety of other artists, of how much consequence it is to them, that this fluid should either be pure, or at least not contaminated with such principles as tend to injure the qualities of the articles they make. This analysis has accordingly employed the attention of the first chemists. Bergmann has written an express treatise on the subject, which may be found in the first volume of the English translation of his Essays. Kirwan published a valuable volume on the analysis of waters. The topography of the place where these waters rise is the first thing to be considered. By examining the ooze formed by them, and the earth or stones through which they are strained and filtered, some judgment may be formed of their contents. In filtering through the earth, and meandering on its surface, they take with them particles of various kinds, which their extreme attenuation renders capable of being suspended in the fluid that serves for their vehicle. Hence we shall sometimes find in these, water, silicious, calcareous, or argillaceous earth; and at other times, though less frequently, sulphur, magnesian earth, or, from the decomposition of carbonated iron, ochre. The following are the ingredients that may occur in mineral waters:—

1. Air is contained in by far the greater number of mineral waters; its proportion does not exceed 1-28th of the bulk of the water.

2. Oxygen gas was first detected in waters by Scheele. Its quantity is usually inconsiderable: and it is incompatible with the presence of sulphuretted hydrogen gas or iron.

3. Hydrogen gas was first detected in Buxton water by Dr. Pearson. Afterward it was discovered in Harrowgate waters by Dr. Garnet, and in those of Lemington Priors by Mr. Lambe.

4. Sulphuretted hydrogen gas constitutes the most conspicuous ingredient in those waters, which are distinguished by the name of hepatic or sulphureous.

The only acids hitherto found in waters, except in combination with a base, are the carbonic, sulphuric, and boracic.

5. Carbonic acid was first discover-

ed in Pyrmont water by Dr. Brownrigg. It is the most common ingredient in mineral waters, 100 cubic inches of the water generally containing from six to forty cubic inches of this acid gas. According to Westrumb, 100 cubic inches of Pyrmont water contain 187 cubic inches of it, or almost double its own bulk.

6. Sulphurous acid has been observed in several of the hot mineral waters in Italy, which are in the neighbourhood of volcanoes.

7. The boracic acid has also been observed in some lakes in Italy.

The only alkali which has been observed in mineral waters, uncombined, is soda; and the only earthy bodies are silex and lime.

8. Dr. Black detected soda in the hot mineral waters of Geysser and Rykum in Iceland; but in most other cases the soda is combined with carbonic acid.

9. Silex was first discovered in waters by Bergmann. It was afterward detected in those of Geysser and Rykum, by Dr. Black, and in those of Karlsbad, by Klaproth. Hassenfratz observed it in the waters of Pougues, as Breze did in those of Pu. It has been found also in many other mineral waters.

10. Lime is said to have been found uncombined in some mineral waters; but this has not been proved in a satisfactory manner.

The only salts hitherto found in mineral waters are the following, sulphates, nitrates, muriates, carbonates, and borates; and of these, the carbonates and muriates occur by far most commonly, and the borates and nitrates most rarely.

11. Sulphate of soda is not uncommon, especially in those mineral waters which are distinguished by the epithet *saline*.

12. Sulphate of ammonia is found in mineral waters near volcanoes.

13. Sulphate of lime is exceedingly common in water. Its presence seems to have been first detected by Dr. Lister, in 1682.

14. Sulphate of magnesia is almost constantly an ingredient in those mineral waters which have purgative properties. It was detected in Epsom waters in 1610, and in 1696 Dr. Grew published a treatise on it.

15. Alum is sometimes found in mineral waters, but it is exceedingly rare.

16. Sulphate of iron occurs sometimes in volcanic mineral waters, and has even been observed in other places.

17. Sulphate of copper is only found in the waters which issue from copper mines.

18. Nitre has been found in some springs in Hungary, but it is exceedingly uncommon.

19. Nitrate of lime was first detected in water by Dr. Home of Edinburgh, in 1756. It is said to occur in some springs in the sandy deserts of Arabia.

20. Nitrate of magnesia is said to have been found in some springs.

21. Muriate of potash is uncommon; but it has lately been discovered in the mineral springs of Uhleaborg in Sweden, by Julin.

22. Muriate of soda is so extremely common in mineral waters, that hardly a single spring has been analyzed without detecting some of it.

23. Muriate of ammonia is uncommon, but it has been found in some mineral springs in Italy and in Siberia.

24. Muriate of barytes is still more uncommon, but its presence in mineral waters has been announced by Bergmann.

25 and 26. Muriates of lime and magnesia are common ingredients.

27. Muriate of alumina has been observed by Dr. Withering, but it is very uncommon.

28. Muriate of manganese was mentioned by Bergmann as sometimes occurring in mineral waters. It has lately been detected by Lambe in the waters of Lemington Priors, but in an extremely limited proportion.

29. The presence of carbonate of potash in mineral waters has been mentioned by several chemists; if it do occur, it must be in a very small proportion.

30. Carbonate of soda is, perhaps, one of the most common ingredients of these liquids, if we except common salt and carbonate of lime.

31. Carbonate of ammonia has been discovered in waters, but it is uncommon.

32. Carbonate of lime is found in almost all waters, and is usually held

in solution by an excess of acid. It appears from the different experiments of chemists, as stated by Mr. Kirwan, and especially from those of Berthollet, that water saturated with carbonic acid is capable of holding in solution 0·002 of carbonate of lime. Now water saturated with carbonic acid, at the temperature of 50°, contains very nearly 0·002 of its weight of carbonic acid. Hence it follows, that carbonic acid, when present in such quantity as to saturate waters, is capable of holding its own weight of carbonate of lime in solution. Thus we see 1000 parts by weight of water, when it contains two parts of carbonic acid, is capable of dissolving two parts of carbonate of lime. When the proportion of water is increased, it is capable of holding the carbonate of lime in solution, even when the proportion of carbonic acid united with it is diminished. Thus, 24,000 parts of water are capable of holding two parts of carbonate of lime in solution, even when they contain only one part of carbonic acid. The greater the proportion of water, the smaller proportion of carbonic acid is necessary to keep the lime in solution; and when the water is increased to a certain proportion, no sensible excess of carbonic acid is necessary. It ought to be remarked also, that water, however small a quantity of carbonic acid it contains, is capable of holding carbonate of lime in solution, provided the weight of the carbonic acid present exceed that of the lime. These observations apply equally to the other earthy carbonates held in solution by mineral waters.

33. Carbonate of magnesia is also very common in mineral waters, and is almost always accompanied by carbonate of lime.

34. Carbonate of alumina is said to have been found in waters, but its presence has not been properly ascertained.

35. Carbonate of iron is by no means uncommon, indeed it forms the most remarkable ingredient in those waters, which are distinguished by the epithet of chalybeate.

36. Borax exists in some lakes in Persia and Thibet, but the nature of these waters has not been ascertained.

37 and 38. The hydrosulphurets of lime and of soda have been frequently detected in those waters which are called sulphurous, or hepatic.

Mr. Westrumb says, that all sulphurous waters contain more or less hydrosulphuret of lime. To detect this he boiled the mineral water, excluding the contact of atmospheric air, to expel the sulphuretted hydrogen gas and carbonic acid. Into the water thus boiled, he poured sulphuric acid, when more sulphuretted hydrogen gas was evolved, and sulphate of lime was thrown down; fuming nitric acid, which separated it from sulphur; and oxalic acid, which expelled sulphuretted hydrogen, and formed oxalate of lime. The water evaporated in open vessels, let fall sulphate of lime, and gave out sulphuretted hydrogen gas. To ascertain the quantity of sulphuretted hydrogen gas and carbonic acid, Mr. Westrumb proceeded as follows: He introduced the sulphurous water into a matrass, till it was filled to a certain point, which he marked; fitted to it a curved tube, which terminated in a long cylinder; filled this cylinder with lime-water for the one experiment, and with acetate of lead, with excess of acid, for the other; luted the apparatus; and boiled the water till no more gas was expelled. When the lime-water is used, carbonate of lime is precipitated in the proportion of 20 grains to every 10 cubic inches of carbonic acid gas; when the solution of acetate of lead, hydrosulphuret of lead is thrown down in the proportion of 19 grains to 10 cubic inches of sulphuretted hydrogen gas. Beside these substances, certain vegetable and animal matters have been occasionally observed in mineral waters. But in most cases these are rather to be considered in the light of accidental mixtures, than of real component parts of the waters in which they occur. From this synoptical view of the different ingredients contained in mineral waters, it is evident that these substances occur in two different distinct states, viz. 1. As being suspended in them; and 2. As being dissolved in them chiefly in the form of a salt. The investigation of mineral waters consists, 1. In the examination of them by the senses. 2. In the examination of them by reagents. 3. In the analysis properly

so called. The examination by the senses consists in observing the effect of the water as to appearance, smell, and taste. The appearance of the water, the instant in which it is pumped out of the well, as well as after it has stood for some time, affords several indications, from which we are enabled to form a judgment concerning its contents. If the water be turbid at the well, the substances are suspended only, and not dissolved; but if the water be clear and transparent at the well, and some time intervenes before it becomes turbid, the contents are dissolved by means of carbonic acid. The presence of this gas is likewise indicated by small bubbles that rise from the bottom of the well, and burst in the air while they are making their escape, though the water, at the same time, perhaps, has not an acid taste. This is the case, according to Count Razoumowski, with respect to the tepid spring in Vallais, and the cold vitriolated chalybeate springs at Astracan. But the most evident proof of a spring containing carbonic acid is the generation of bubbles on the water being shaken, and their bursting with more or less noise, while the air is making its escapes. The sediment deposited by the water in the well, is likewise to be examined: if it be yellow, it indicates the presence of iron; if black, that of iron combined with sulphur; but chalybeate waters being seldom sulphuretted, the latter occurs very rarely. As to the colour of the water itself, there are few instances where this can give any indication of its contents, as there are not many substances that colour it. The odour of the water serves chiefly to discover the presence of sulphuretted hydrogen in it; such waters as contain this substance, have a peculiar fœtid smell, somewhat resembling rotten eggs. The taste of a spring, provided it be perfectly ascertained by repeated trials, may afford some useful indications with respect to the contents. It may be made very sensible by tasting water, in which the various salts that are usually found in such waters are dissolved in various proportions. There is no certain dependence, however, to be placed on this mode of investigation; for in many springs, the taste of sulphate of soda is disguised by that of the sea salt united with it. The water too is not only to be tasted at the spring, but after it has stood for some time. This precaution must be particularly observed with respect to such waters as are impregnated with carbonic acid; for the other substances contained in them make no impression on the tongue, till the carbonic acid has made its escape; and it is for the same reason, that these waters must be evaporated in part, and then tasted again. Though the specific gravity of any water contributes but very little towards determining its contents, still it may not be entirely useless to know the specific weight of the water, the situation of the spring, and the kind of sediment deposited by it. The examination of the water by means of re-agents, shows what they contain, but not how much of each principle. In many instances this is as much as the inquiry demands; and it is always of use to direct the proceedings in the proper analysis. It is absolutely necessary to make the experiment with water just taken up from the spring, and afterwards with such as has been exposed for some hours to the open air; and sometimes a third essay is to be made with a portion of the water that has been boiled and afterwards filtered. If the water contain but few saline particles it must be evaporated; as even the most sensible re-agents do not in the least affect it, if the salts, the presence of which is to be discovered by them, are diluted with too great a quantity of water. Now, it may happen, that a water shall be impregnated with a considerable number of saline particles of different kinds, though some of them may be present in too small a quantity; for which reason the water must be examined a second time, after having been boiled down to three-fourths. The substances of which the presence is discoverable by re-agents, are:—

1. Carbonic acid. When this is not combined with any base, or not with sufficient to neutralize it, the addition of lime-water will throw down a precipitate, soluble with effervescence in muriatic acid. The infusion of litmus is reddened by it; but the red colour gradually disappears, and may be again restored by

the addition of more of the mineral water. When boiled, it loses the property of reddening the infusion of litmus. According to Pfaff, the most sensible test of this acid is acetate of lead.

2. The mineral acids, when present uncombined in water, give the infusion of litmus a permanent red, even though the water has been boiled. Bergmann has shown, that paper stained with litmus is reddened when dipped into water containing $\frac{1}{3527}$ of sulphuric acid.

3. Water containing sulphuretted hydrogen gas, is distinguished by the following properties: It exhales the peculiar odour of sulphuretted hydrogen gas. It reddens the infusion of litmus fugaciously. It blackens paper dipped into a solution of lead, and precipitates the nitrate of silver black or brown.

4. Alkalis, and alkaline and earthy carbonates, are distinguished by the following tests:—The infusion of turmeric, or paper stained with turmeric, is rendered brown by alkalis; or reddish-brown, if the quantity be minute. This change is produced when the soda in water amounts only to $\frac{1}{2417}$ part. Paper stained with brazil wood, or the infusion of brazil wood, is rendered blue; but this change is produced also by the alkaline and earthy carbonates. Bergmann ascertained that water containing $\frac{1}{5711}$ part of carbonate of soda, renders paper stained with brazil wood, blue. Litmus paper reddened by vinegar, is restored to its original blue colour. This change is produced by the alkaline and earthy carbonates also. When these changes are fugacious, we may conclude, that the alkali is ammonia.

5. Fixed alkalies exist in water that occasions a precipitate with muriate of magnesia after being boiled. Volatile alkali may be distinguished by the smell; or it may be obtained in the receiver by distilling a portion of the water gently, and then it may be distinguished by the above tests.

6. Earthy and metallic carbonates are precipitated by boiling the water containing them; except carbonate of magnesia, which is precipitated but imperfectly.

7. Iron is discovered by the following tests:—The addition of tincture of galls gives water, containing iron, a purple or black colour. This test indicates the presence of a very minute portion of iron. If the tincture have no effect upon the water, after boiling, though it colours it before, the iron is in the state of a carbonate. The following observations of Westrumb on the colour which iron gives to galls, as modified by other bodies, deserve attention. A violet indicates an alkaline carbonate, or earthy salt. Dark purple indicates other alkaline salts. Purpleish-red indicates sulphuretted hydrogen gas. Whitish, and then black, indicates sulphate of lime. Mr. Phillips has lately ascertained, that, while the iron is a little oxided, the presence of lime rather facilitates the application of this test; but the lime prevents the test from acting, provided the iron be considerably oxidized. The Prussian alkali occasions a blue precipitate in water, containing iron. If an alkali be present, the blue precipitate does not appear unless the alkali is saturated with an acid.

8. Sulphuric acid exists in waters that form a precipitate with the following solutions:—Muriate, nitrate, or acetate of barytes, strontian, or lime, nitrate or acetate of lead. Of these the most powerful by far is muriate of barytes, which is capable of detecting the presence of sulphuric acid uncombined, when it does not exceed the millionth part of the water. Acetate of lead is next in point of power. The muriates are more powerful than the nitrates. The calcareous salts are least powerful. All these tests are capable of indicating a much smaller proportion of uncombined sulphuric acid, than when it is combined with a base. To render muriate of barytes a certain test of sulphuric acid, the following precautions must be observed:—The muriate must be diluted; the alkalis or alkaline carbonates, if the water contain any, must be previously saturated with muriatic acid; the precipitate must be insoluble in muriatic acid; if boracic acid be suspected, muriate of strontian must be tried, which is not precipitated by boracic acid. The hydro-sulphurets precipitate barytic solutions, but their presence is easily discovered by the smell.

9. Muriatic acid is detected by nitrate of silver, which occasions a white precipitate, or a cloud, in water containing an exceedingly minute portion of this acid. To render this test certain, the following precautions are necessary:—The alkalis or carbonates must be previously saturated with nitric acid. Sulphuric acid, if any be present, must be previously removed by means of nitrate of barytes. The precipitate must be insoluble in nitric acid. Pfaff says, that the mild nitrate of mercury is the most sensible test of muriatic acid; and that the precipitate is not soluble in an excess of any acid.

10. Boracic acid is detected by means of acetate of lead, with which it forms a precipitate insoluble in acetic acid. But to render this test certain, the alkalis and earths must be previously saturated with acetic acid, and the sulphuric and muriatic acids removed by means of acetate of strontian and acetate of silver.

11. Barytes is detected by the insoluble white precipitate, which it forms with diluted sulphuric acid.

12. Lime is detected by means of oxalic acid, which occasions a white precipitate in water containing a very minute proportion of this earth. To render this test decisive, the following precautions are necessary:—The mineral acids (if any be present) must be previously saturated with an alkali. Barytes (if any be present) must be previously removed by means of sulphuric acid. Oxalic acid precipitates magnesia but very slowly, whereas it precipitates lime instantly.

13. Magnesia and alumina. The presence of these earths is ascertained by the following tests:—Pure ammonia precipitates them both, and no other earth, provided the carbonic acid have been previously separated by a fixed alkali and boiling. Lime-water precipitates only these two earths, provided the carbonic acid be previously removed, and the sulphuric acid also, by means of nitrate of barytes.—The alumina may be separated from the magnesia, after both have been precipitated together, either by boiling the precipitate in caustic potash, which dissolves the alumina and leaves the magnesia; or the precipitate may be dissolved in muriatic acid, precipitated by an alkaline carbonate, dried in the temperature of 100°, and then exposed to the action of diluted muriatic acid, which dissolves the magnesia without touching the alumina.

14. Silex may be ascertained by evaporating a portion of water to dryness, and redissolving the precipitate in muriatic acid. The silex remains behind undissolved.—By these means we may detect the presence of the different substances commonly found in waters; but as they are generally combined so as to form salts, it is necessary we should know what these combinations are. This is a more difficult task, which Mr. Kirwan teaches us to accomplish by the following methods:—

1. To ascertain the presence of the different sulphates.—The sulphates which occur in water are seven; but one of these, namely, *sulphate of copper*, is so uncommon, that it may be excluded altogether. The same remark applies to sulphate of ammonia. It is almost unnecessary to observe, that no sulphate need be looked for, unless both its acids and base have been previously detected in the water.—Sulphate of soda may be detected by the following method: Free the water (to be examined) of all earthy sulphates, by evaporating it to one-half, and adding lime-water as long as any precipitate appears. By these means the earths will all be precipitated, except lime, and the only remaining earthy sulphate will be sulphate of lime, which will be separated by evaporating the liquid till it becomes concentrated, and then dropping into it a little alcohol, and, after filtration, adding a little oxalic acid. With the water thus purified, mix solution of lime. If a precipitate appear, either immediately or on the addition of a little alcohol, it is a proof, that sulphate of potash or of soda is present: which of the two may be determined by mixing some of the purified water with acetate of barytes. Sulphate of barytes precipitates. Filter and evaporate to dryness. Digest the residuum in alcohol. It will dissolve the alkaline acetate. Evaporate to dryness, and the dry salt will deliquesce, if it be acetate of potash; but effloresce, if it be acetate of soda.—Sulphate of lime may be detected by evaporating the

water suspected to contain it to a few ounces. A precipitate appears, which, if it be sulphate of lime, is soluble in 500 parts of water; and the solution affords a precipitate with the muriate of barytes, oxalic acid, carbonate of magnesia, and alcohol.—Alum may be detected by mixing carbonate of lime with the water suspected to contain it. If a precipitate appear, it indicates the presence of alum, or at least sulphate of alumina, provided the water contains no muriate of barytes or metallic sulphates. The first of these salts is incompatible with alum: the second may be removed by the alkaline prussiates. When precipitate is produced in water by muriate of lime, carbonate of lime, and muriate of magnesia, we may conclude, that it contains alum or sulphate of alumina.—Sulphate of magnesia may be detected by means of hydrosulphuret of strontian, which occasions an immediate precipitate with this salt, and with no other; provided the water be previously deprived of alum (if any be present) by means of carbonate of lime, and provided also that it contains no uncombined acid.—Sulphate of iron is precipitated from water by alcohol, and then it may be easily recognized by its properties.

2. To ascertain the presence of the different muriates.—The muriates found in waters amount to eight, or to nine, if muriate of iron be included. The most common by far is muriate of soda.—Muriate of soda and of potash may be detected by the following method: separate the sulphuric acid by alcohol and nitrate of barytes. Decompose the earthy nitrates and muriates by adding sulphuric acid. Expel the excess of muriatic and nitric acids by heat. Separate the sulphates thus formed by alcohol and barytes water. The water thus purified can contain nothing but alkaline nitrates and muriates. If it form a precipitate with acetate of silver, we may conclude, that it contains muriate of soda or of potash. To ascertain which, evaporate the liquid thus precipitated to dryness. Dissolve the acetate in alcohol, and again evaporate to dryness. The salt will deliquesce, if it be acetate of potash; but effloresce, if it be acetate of soda.—Muriate of barytes may be detected by sulphuric acid, as it is the only barytic salt hitherto found in water.—Muriate of lime may be detected by the following method: free the water from sulphate of lime and other sulphates, by evaporating it to a few ounces, mixing it with alcohol, and adding, last of all, nitrate of barytes, as long as any precipitate appears. Filter the water; evaporate to dryness; treat the dry mass with alcohol; evaporate the alcohol to dryness; and dissolve the residuum in water. If this solution give a precipitate with acetate of silver and oxalic acid, it may contain muriate of lime. It must contain it in that case, if, after being treated with carbonate of lime, it give no precipitate with ammonia. If the liquid in the receiver give a precipitate with nitrate of silver, muriate of lime existed in the water.—Muriate of magnesia may be detected by separating all the sulphuric acid by means of nitrate of barytes. Filter, evaporate to dryness, and treat the dry mass with alcohol. Evaporate the alcoholic solution to dryness, and dissolve the residuum in water. The muriate of magnesia (if the water contained any) will be found in this solution. Let us suppose, that, by the tests formerly described, the presence of muriatic acid and of magnesia, in this solution, has been ascertained. In that case, if carbonate of lime afford no precipitate, and if sulphuric acid and evaporation, together with the addition of a little alcohol, occasion no precipitate, the solution contains only muriate of magnesia. If these tests give precipitates, we must separate the lime which is present by sulphuric acid and alcohol, and distil off the acid with which it was combined. Then the magnesia is to be separated by the oxalic acid and alcohol, and the acid with which it was united is to be distilled off. If the liquid in the retort give a precipitate with nitrate of silver, the water contains muriate of magnesia.—Muriate of alumina may be discovered by saturating the water (if it contain an excess of alkali) with nitric acid, and by separating the sulphuric acid by means of nitrate of barytes. If the liquid, thus purified, give a precipitate with carbonate of lime, it contains muri-

ate of alumina. The muriate of iron or of manganese (if any be present) is also decomposed, and the iron precipitated by this salt. The precipitate may be dissolved in muriatic acid, and the alumina, iron, and manganese (if they be present) may be separated by the rules laid down below.

3. To ascertain the presence of the different nitrates. The nitrates but seldom occur in waters, but when they do, they may be detected by the following results:—Alkaline nitrates may be detected by freeing the water examined from sulphuric acid by means of acetate of barytes, and from muriatic acid by acetate of silver. Evaporate the filtered liquid, and treat the dry mass with alcohol; what the alcohol leaves can consist only of the alkaline nitrates and acetate of lime. Dissolve it in water. If carbonate of magnesia occasion a precipitate, lime is present. Separate the lime by means of carbonate of magnesia. Filter and evaporate to dryness, and treat the dried mass with alcohol. The alcohol now leaves only the alkaline nitrates, which may be easily recognised and distinguished by their respective properties. Nitrate of lime.—To detect this salt, concentrate the water, and mix it with alcohol to separate the sulphates. Filter, and distil off the alcohol; then separate the muriatic acid by acetate of silver. Filter, evaporate to dryness, and dissolve the residuum in alcohol. Evaporate to dryness, and dissolve the dry mass in water. If this last solution indicate the presence of lime by the usual tests, the water contained nitrate of lime. To detect nitrate of magnesia, the water is to be freed from sulphates and muriates, exactly as described in the last paragraph. The liquid thus purified is to be evaporated to dryness, and the residuum treated with alcohol. The alcoholic solution is to be evaporated to dryness, and the dry mass dissolved in water. To this solution potash is to be added, as long as any precipitate appears. The solution, filtered, and again evaporated to dryness, is to be treated with alcohol. If it leave a residuum consisting of nitre (the only residuum which it can leave), the water contained nitrate of magnesia.

Such are the methods by which the presence of the different saline contents of waters may be ascertained. The labour of analysis may be considerably shortened, by observing that the following salts are incompatible with each other, and cannot exist together in water, except in very minute proportions:—

Salts.	Incompatible with
Fixed alkaline sulphates	Nitrates of lime and magnesia. Muriates of lime and magnesia.
Sulphate of lime	Alkalis, Carbonate of magnesi Muriate of barytes.
Alum	Alkalis, Muriate of barytes, Nitrate, muriate, carbonate of lime, Carbonate of magnesia.
Sulphate of magnesia	Alkalis, Muriate of barytes, Nitrate and muriate of lime.
Sulphate of iron.	Alkalis, Muriate of barytes, Earthy carbonates.
Muriate of barytes	Sulphates, Alkaline carbonates, Earthy carbonates.
Muriate of lime	Sulphates, except of lime, Alkaline carbonates, Earthy carbonates.
Muriate of magnesia	Alkaline carbonate, Alkaline sulphates.
Nitrate of lime	Alkaline carbonates, Carbonate of magnesia and alumina, Sulphates, except of lime.

Besides the substances above described, there is sometimes found in water a quantity of bitumen combined with alkali, and in the state of soap. In such waters acids occasion a coagulation: and the coagulum collected on a filter discovers its bituminous nature by its combustibility. Water also sometimes contains extractive matter, the presence of which may be detected by means of nitrate of silver. The water suspected to contain it must be freed from sulphuric and nitric acid by means of nitrate of lead: after this, if it give a brown precipitate with nitrate of silver, we may conclude that extractive matter is present. But it is not sufficient to know that a mineral water contains certain ingredients;

it is necessary to ascertain the proportions of these, and thus we arrive at their complete analysis.

1. The different aërial fluids ought to be first separated and estimated. For this purpose, a retort should be filled two-thirds with the water, and connected with a jar full of mercury, standing over a mercurial trough. Let the water be made to boil for a quarter of an hour. The aërial fluids will pass over into the jar. When the apparatus is cool, the quantity of air expelled from the water may be determined either by bringing the mercury within or without the jar to a level; or if this cannot be done, by reducing the air to the proper density by calculation. The air of the retort ought to be carefully subtracted, and the jar should be divided into cubic inches and tenths. The only gaseous bodies contained in water are, common air, oxygen gas, nitrogen gas, carbonic acid, sulphuretted hydrogen gas, and sulphurous acid. The last two never exist in water together. The presence of either of them must be ascertained previously by the application of the proper tests. If sulphuretted hydrogen gas be present, it will be mixed with the air contained in the glass jar, and must be separated before this air be examined. For this purpose the jar must be removed into a tub of warm water, and nitric acid introduced, which will absorb the sulphuretted hydrogen. The residuum is then to be again put into a mercurial jar and examined. If the water contain sulphurous acid, this previous step is not necessary. Introduce into the air a solution of pure potash, and agitate the whole gently. The carbonic acid and sulphurous acid gas will be absorbed, and leave the other gases. The bulk of this residuum, subtracted from the bulk of the whole, will give the bulk of the carbonic acid and sulphurous acid absorbed. Evaporate the potash slowly, almost to dryness, and leave it exposed to the atmosphere. Sulphate of potash will be formed, which may be separated by dissolving the carbonate of potash by means of diluted muriatic acid, and filtering the solution. 100 grains of sulphate of potash indicate 36·1 grains of sulphurous acid, or 53·66 cubic inches of that acid in the state of gas. The bulk of sulphurous acid gas ascertained by this method, subtracted from the bulk of the gas absorbed by the potash, gives the bulk of the carbonic acid gas. Now 100 cubic inches of carbonic acid, at the temperature of 60° and barometer 30 inches, weigh 46·6 grains. Hence it is easy to ascertain its weight. The gas remaining may be examined by the common eudiometrical processes. When a water contains sulphuretted hydrogen gas, the bulk of this gas is to be ascertained in the following manner:—Fill three-fourths of a jar with the water to be examined, and invert it in a water trough, and introduce a little nitrous gas. This gas, mixing with the air in the upper part of the jar, will form nitrous acid, which will render the water turbid, by decomposing the sulphuretted hydrogen and precipitating sulphur. Continue to add nitrous gas at intervals as long as red fumes appear, then turn up the jar and blow out the air. If the hepatic smell continue, repeat this process. The sulphur precipitated indicates the proportion of hepatic gas in the water; one grain of sulphur indicating the presence of nearly three cubic inches of this gas.

2. After having estimated the gaseous bodies, the next step is to ascertain the proportion of the earthy carbonates. For this purpose it is necessary to deprive the water of its sulphuretted hydrogen, if it contain any. This may be done, either by exposing it to the air for a considerable time, or treating it with litharge. A sufficient quantity of the water, thus purified if necessary, is to be boiled for a quarter of an hour, and filtered when cool. The earthy carbonates remain on the filter. The precipitate thus obtained may be carbonate of lime, of magnesia, of iron, of alumina, or even sulphate of lime. Let us suppose all these substances to be present together. Treat the mixture with diluted muriatic acid, which will dissolve the whole except the alumina and sulphate of lime. Dry this residuum in a red-heat, and note the weight. Then boil it in carbonate of soda, saturate the soda with muriatic acid, and boil the mixture for half an hour. Carbonate of lime and alumina precipitate. Dry this precipitate, and treat it with acetic

acid. The lime will be dissolved, and the alumina will remain. Dry it and weigh it. Its weight subtracted from the original weight, gives the proportion of sulphate of lime. The muriatic solution contains lime, magnesia, and iron. Add ammonia as long as a reddish precipitate appears. The iron and part of the magnesia are thus separated. Dry the precipitate, and expose it to the air for some time in a heat of 200°; then treat it with acetic acid to dissolve the magnesia, which solution is to be added to the muriatic solution. The iron is to be re-dissolved in muriatic acid, precipitated by an alkaline carbonate, dried and weighed. Add sulphuric acid to the muriatic solution as long as any precipitate appears; then heat the solution and concentrate. Heat the sulphate of lime thus obtained to redness, and weigh it: 100 grains of it are equivalent to 74·7 of carbonate of lime dried. Precipitate the magnesia by means of carbonate of soda. Dry it and weigh it. But as part remains in solution, evaporate to dryness, and wash the residuum with a sufficient quantity of distilled water, to dissolve the muriate of soda and sulphate of lime, if any be still present: what remains behind is carbonate of magnesia. Weigh it, and add its weight to the former. The sulphate of lime, if any, must also be separated and weighed.

3. We have next to ascertain the proportion of mineral acids or alkalies, if any be present uncombined. The acids which may be present, omitting the gaseous, are the sulphuric, muriatic, and boracic. The proportion of sulphuric acid is easily determined. Saturate it with barytes water, and ignite the precipitate. 100 grains of sulphate of barytes thus formed indicate 34·0 of real sulphuric acid. Saturate the muriatic acid with barytes water, and then precipitate the barytes by sulphuric acid. 100 parts of the ignited precipitate are equivalent to 23·73 grains of real muriatic acid. Precipitate the boracic acid by means of acetate of lead. Decompose the borate of lead by boiling it in sulphuric acid. Evaporate to dryness. Dissolve the boracic acid in alcohol, and evaporate the solution; the acid left behind may be weighed. To estimate the proportion of alkaline carbonate present in a water containing it, saturate it with sulphuric acid, and note the weight of real acid necessary. Now 100 grains of real sulphuric acid saturate 120·0 potash, and 80·0 soda.

4. The alkaline sulphates may be estimated by precipitating their acid by means of nitrate of barytes, having previously freed the water from all other sulphates; for 14·75 grains of ignited sulphate of barytes indicate 9·0 grains of dried sulphate of soda; while 14·75 sulphate of barytes indicate 11 of dry sulphate of potash. Sulphate of lime is easily estimated by evaporating the liquid containing it to a few ounces (having previously saturated the earthy carbonates with nitric acid), and precipitating the sulphate of lime by means of weak alcohol. It may then be dried and weighed. The quantity of alum may be estimated by precipitating the alumina by carbonate of lime or of magnesia (if no lime be present in the liquid). Eleven grains of the alumina, heated to incandescence, indicate 100 of crystallized alum, or 55 of dried salt. Sulphate of magnesia may be estimated, provided no other sulphate be present, by precipitating the acid by means of a barytic salt, as 14·75 parts of ignited sulphate of barytes indicate 7·46 of sulphate of magnesia. If sulphate of lime, and no other sulphate, accompany it, this may be decomposed, and the lime precipitated by carbonate of magnesia. The weight of the lime thus obtained, enables us to ascertain the quantity of sulphate of lime contained in the water. The whole of the sulphuric acid is then to be precipitated by barytes. This gives the quantity of sulphuric acid; and subtracting the portion which belongs to the sulphate of lime, there remains that which was combined with the magnesia, from which the sulphate of magnesia may be easily estimated. If sulphate of soda be present, no earthy nitrate or muriate can exist. Therefore, if no other earthy sulphate be present, the magnesia may be precipitated by soda, dried and weighed; 2·46 grains of which indicate 7·46 grains of dried sulphate of magnesia. The same process succeeds when sulphate of lime accompanies these two sulphates; only in this case the pre-

cipitate, which consists both of lime and magnesia, is to be dissolved in sulphuric acid, evaporated to dryness, and treated with twice its weight of cold water, which dissolves the sulphate of magnesia, and leaves the other salt. Let the sulphate of magnesia be evaporated to dryness, exposed to a heat of 400°, and weighed. The same process succeeds if alum be present instead of sulphate of lime. The precipitate in this case, previously dried, is to be treated with acetic acid, which dissolves the magnesia, and leaves the alumina. The magnesia may be again precipitated, dried, and weighed. If sulphate of iron be present, it may be separated by exposing the water to the air for some days, and mixing with it a portion of alumina. Both the oxide of iron, and the sulphate of alumina, thus formed, precipitate in the state of an insoluble powder. The sulphate of magnesia may then be estimated by the rules above given. Sulphate of iron may be estimated by precipitating the iron by means of prussic alkali, having previously determined the weight of the precipitate produced by the prussiate in a solution of a given weight of sulphate of iron in water. If muriate of iron be also present, which is a very rare case, it may be separated by evaporating the water to dryness, and treating the residuum with alcohol, which dissolves the muriate, and leaves the sulphate.

5. If muriate of potash, or of soda, without any other salt, exist in water, we have only to decompose them by nitrate of silver, and dry the precipitate; for 18·2 of muriate of silver indicate 9·5 of muriate of potash; and 18·2 of muriate of silver indicate 7·5 of common salt. The same process is to be followed if the alkaline carbonates be present; only these carbonates must be previously saturated with sulphuric acid; and we must precipitate the muriatic acid by means of sulphate of silver instead of nitrate. The presence of sulphate of soda does not injure the success of this process. If muriate of ammonia accompany either of the fixed alkaline sulphates, without the presence of any other salt, decompose the sal ammoniac by barytes water, expel the ammonia by boiling, precipitate the barytes by diluted sulphuric acid and saturate the muriatic acid with soda. The sulphate of barytes thus precipitated, indicates the quantity of muriate of ammonia, 14·75 grains of sulphate indicating 67·0 grains of this salt. If any sulphates be present in the solution, they ought to be previously separated. If common salt be accompanied by muriate of lime, muriate of magnesia, muriate of alumina, or muriate of iron, or by all these together, without any other salt, the earths may be precipitated by barytes water, and re-dissolved in muriatic acid. They are then to be separated from each other by the rules formerly laid down, and their weight, being determined, indicates the quantity of every particular earthy muriate contained in the water. For 50 grains of lime indicate 100 of dried muriate of lime; 30 grains of magnesia indicate 100 of the muriate of that earth; and 21·8 grains of alumina indicate 100 of the muriate of alumina. The barytes is to be separated from the solution by sulphuric acid, and the muriatic acid expelled by heat, or saturated with soda; the common salt may then be ascertained by evaporation, subtracting in the last case the proportion of common salt indicated by the known quantity of muriatic acid, from which the earths had been separated. When sulphates and muriates exist together, they ought to be separated either by precipitating the sulphates by means of alcohol, or by evaporating the whole to dryness, and dissolving the earthy muriates in alcohol. The salts thus separated may be estimated by the rules already laid down When alkaline and earthy muriates and sulphate of lime occur together, the last is to be decomposed by means of muriate of barytes. The precipitate ascertains the weight of sulphate of lime contained in the water. The estimation is then to be conducted as when nothing but muriates are present, only from the muriate of lime that proportion of muriate must be deducted, which is known to have been formed by the addition of the muriate of barytes. When muriates of soda, magnesia, and alumina, are present together with sulphates of lime and magnesia, the water to be examined ought to be divided into

two equal portions. To the one portion add carbonate of magnesia, till the whole of the lime and alumina is precipitated. Ascertain the quantity of lime, which gives the proportion of sulphate of lime. Precipitate the sulphuric acid by muriate of barytes. This gives the quantity contained in the sulphate of magnesia and sulphate of lime; subtracting this last portion, we have the quantity of sulphate of magnesia. From the second portion of water, precipitate all the magnesia and alumina by means of lime-water. The weight of these earths enables us to ascertain the weight of muriate of magnesia and of alumina contained in the water, subtracting that part of the magnesia which existed in the state of sulphate, as indicated by the examination of the first portion of water. After this estimation, precipitate the sulphuric acid by barytes water, and the lime by carbonic acid. The liquid, evaporated to dryness, leaves the common salt.

6. It now only remains to explain the method of ascertaining the proportion of the nitrates which may exist in waters. When nitre accompanies sulphates and muriates without any other nitrates, the sulphates are to be decomposed by acetate of barytes, and the muriates by acetate of silver. The water, after filtration, is to be evaporated to dryness, and the residuum treated with alcohol, which dissolves the acetates, and leaves the nitre, the quantity of which may be easily calculated. If an alkali be present, it ought to be previously saturated with sulphuric or muriatic acid. If nitre, common salt, nitrate of lime, and muriate of lime or magnesia, be present together, the water ought to be evaporated to dryness, and the dry mass treated with alcohol, which takes up the earthy salts. From the residuum, re-dissolved in water, the nitre may be separated, and calculated as in the last case. The alcoholic solution is to be evaporated to dryness, and the residuum re-dissolved in water. Let us suppose it to contain muriate of magnesia, nitrate of lime, and muriate of lime. Precipitate the muriatic acid by nitrate of silver, which gives the proportion of muriate of magnesia and of lime. Separate the magnesia by means of carbonate of lime, and note its quantity. This gives the quantity of muriate of magnesia; and subtracting the muriatic acid contained in that salt from the whole acid indicated by the precipitate of silver, we have the proportion of muriate of lime. Lastly, saturate the lime added to precipitate the magnesia with nitric acid. Then precipitate the whole of the lime by sulphuric acid; and subtracting from the whole of the sulphate thus formed, that portion formed by the carbonate of lime added, and by the lime contained in the muriate, the residuum gives us the lime contained in the original nitrate; and 35 grains of lime form 100 of dry nitrate of lime.

In a general view of the geology of England, the hot wells and warm springs must not be neglected. The warm springs in Derbyshire vary in temperature from 58 to 82 degrees, though each spring preserves the same degree of heat except in situations where the waters have been intermixed with those near the surface, by excavations made in mines, or by other causes. The effects of internal heat appear to extend under the whole district that contains basaltic amygdaloid or toad stone; for the rivers of this county are rarely frozen except in still situations, when the thermometer is little more than 10 degrees above zero. A very sensible degree of warmth may be perceived in the water of the Crumford canal between Matlock and Crich, and numerous exhalations from warm springs may be frequently seen rising from the neighbouring hills. The warm springs of Bath and Bristol have a much higher temperature than those of Derbyshire, owing, probably, to their being less intermixed with the waters near the surface, as they issue from fewer apertures. It has been remarked that warm springs are principally confined to basaltic and volcanic countries. In Iceland, in the Azores, in Sicily, in Italy, and various parts of Europe not distant from volcanic or basaltic rocks, numerous warm springs exist; but in the whole of the United States of America, where there are few basaltic rocks, warm springs are scarcely known. These remarks are confirmed by the situation of the warm springs in Der-

byshire, surrounded by beds of basaltic rock nearly allied to lava. The hot springs of Somersetshire are situated on the western side of the island, not far from the line of basaltic rocks extending from the coasts of Wales and Ireland to the Hebrides, and terminating at its northern extremity, in the volcanic mountains of Iceland. It will scarcely be denied that the boiling fountains or geysers of that country, and the warm springs of Italy and Sicily, derive their temperature from subterranean fire; and it is contrary to the established rules of philosophy to multiply causes and seek for other sources of heat in the waters of Bath or Buxton. The former have preserved their high temperature for two thousand years; hence it is obvious that they rise from a great depth, far below the effects of those changes which take place near the surface. It is further remarkable, that the hot wells of Bath and the boiling fountains of Iceland both contain in solution siliceous earth, one of the most insoluble substances in nature; the similarity of their contents affords a further confirmation that they derive their heat from the same cause; and we have every proof the subject will admit of, that this cause is subterranean fire.

Temperature of the Hot Waters in England, and some other parts of Europe.

	Fahrenheit.
Bristol - - -	74°
Matlock - - -	68
Buxton - - -	82
Bath - - -	116
Vichy, Auvergne -	120
Carlsbad, Bohemia -	165
Aix-la-Chapelle, Flanders - - -	143
Borset, near Aix-la-Chapelle - -	132
Bareges, South of France - - -	120

WATER, (OXYGENIZED), or deutoxide of hydrogen; lately formed by M. Thenard. The deutoxide of barium being dissolved in water and sulphuric acid added, the protoxide of barium or barytes falls down, leaving the oxygen combined with the water. It contains, at 32 degrees Fahrenheit, when saturated, twice the quantity of oxygen of common water. Specific gravity 1·453. In consequence of this great density, when it is poured into common water it falls down like a sort of syrup, though it is very soluble. When applied to the tongue it whitens it, thickens the saliva, and produces in the organs of taste a sensation which approaches to that of tartar emetic. Besides the oxide of silver there are several other oxides, which act with violence on oxygenated water; for example, the peroxide of manganese, that of cobalt, the oxides of lead, platinum, gold, iridium, rhodium, palladium. Several metals in a state of extreme division, occasion the same phenomenon; such as silver, platinum, gold, osmium, iridium, rhodium, palladium. The acids render the oxygenated water more stable. Urea, albumen, and gelatin, do not disengage oxygen from water, even very much oxygenated. But the tissue of the lungs cut into thin slices and well washed; that of the kidneys and the spleen, drive the oxygen out of the water.

WAVELLITE. Colour greyish-white; shining, pearly; translucent; as hard as fluor spar; brittle; specific gravity 2·3 to 2·8. Its constituents are, alumina 70, lime 1·4, water 26·2.—*Davy.* At Barnstaple in Devonshire, where it was first found by Dr. Wavell, it traverses slate-clay, in the form of small contemporaneous veins.

WAX, is an oily concrete matter, gathered by bees from plants. Proust says, that the bloom on fruit is real wax; and that it is wax spread over leaves which prevents them from being wetted, as on the cabbage-leaf. He likewise finds it in the fecula of some vegetables, particularly in that of the small house leek, in which it abounds. Huber, however, asserts, from his observations, that the wax in bee-hives is an artificial production, made by the bees from honey; that they cannot procure it unless they have honey or sugar for the purpose; and that raw sugar affords more than honey. It was long considered as a resin, from some properties common to it with resins. Like them, it furnishes an oil and an acid by distillation, and is soluble in all oils; but in several respects it differs sensibly from resins. Like these, wax has not a strong aromatic taste and smell, but a very weak smell, and when pure, no taste. With the heat

of boiling water no principles are distilled from it; whereas, with that heat, some essential oil, or at least a spiritus rector, is obtained from every resin. Farther, wax is less soluble in alcohol. If wax be distilled with a heat greater than that of boiling water, it may be decomposed, but not so easily as resins can. By this distillation a small quantity of water is first separated from the wax, and then some very volatile and very penetrating acid, accompanied with a small quantity of a very fluid and very odoriferous oil. As the distillation advances, the acid becomes more and more strong, and the oil more and more thick, till its consistence is such that it becomes solid in the receiver, and is then called butter of wax. When the distillation is finished, nothing remains but a small quantity of coal, which is almost incombustible. Wax cannot be kindled unless it is previously heated and reduced into vapours: in which respect it resembles fat oils. The oil of butter of wax may, by repeated distillations, be attenuated and rendered more and more fluid, because some portion of acid is thereby separated from these substances; which effect is similar to what happens in the distillation of other oils and oily concretes; but this remarkable effect attends the repeated distillation of oil and butter of wax, that they become more and more soluble in alcohol, and that they never acquire greater consistence by evaporation of their more fluid parts. Boerhaave kept butter of wax in a glass vessel open, or carelessly closed, during twenty years, without acquiring a more solid consistence. It may be remarked, that wax, its butter, and its oil, differ entirely from essential oils and resins in all the above-mentioned properties, and that in all these they perfectly resemble sweet oils. Hence Macquer concludes, that wax resembles resins only in being an oil rendered concrete by an acid; but that it differs essentially from these in the kind of the oil, which, in resins, is of the nature of essential oils, while in wax, and in other analogous oily concretions, (as butter of milk, butter of cocoa, fat of animals, spermaceti, and myrtle wax), it is of the nature of mild unctuous oils, that are not aromatic, and not volatile, and are obtained from vegetables by expression. It seems probable that the acidifying principle, or oxygen, and not an actual acid, may be the leading cause of the solidity, or low fusibility of wax. Wax is very useful, especially as a better material than any other for candles. Wax may be deprived of its natural yellow disagreeable colour, and be perfectly whitened by exposure to the united action of air and water, by which method the colour of many substances may be destroyed. The art of bleaching wax consists in increasing its surface; for which purpose it must be melted with a degree of heat not sufficient to alter its quality, in a caldron so disposed, that the melted wax may flow gradually through a pipe at the bottom of the caldron into a large tub filled with water, in which is fitted a large wooden cylinder, that turns continually round its axis, and upon which the melted wax falls. As the surface of this cylinder is always moistened with cold water, the wax falling upon it does not adhere to it, but quickly becomes solid and flat, and acquires the form of ribbands. The continual rotation of the cylinder carries off these ribbands as fast as they are formed, and distributes them through the tub. When all the wax that is to be whitened is thus formed, it is put upon large frames covered with linen cloth, which are supported about a foot and a half above the ground, in a situation exposed to the air, the dew, and the sun. The thickness of the several ribbands thus placed upon the frames, ought not to exceed an inch and a half, and they ought to be moved from time to time, that they may all be equally exposed to the action of the air. If the weather be favourable, the colour will be changed in the space of some days. It is then to be re-melted and formed into ribbands, and exposed to the action of the air as before. These operations are to be repeated till the wax is rendered perfectly white, and then it is to be melted into cakes, or formed into candles. Wax consists, according to MM. Gay Lussac and Thenard, of

Oxygen	5·544
Hydrogen	12·672
Carbon	81·784
	100·000

Wax is employed for many purposes in several arts. It is also used in medicine as a softening, emollient and relaxing remedy: but it is only used externally, mixed with other substances.

WELD, or WOALD, (reseda luteola, Linn.) is a plant cultivated in Kent, Herefordshire, and many other parts of this kingdom. The whole of the plant is used for dyeing yellow; though some assert that the seeds only afford the colouring matter. Two sorts of weld are distinguished: the bastard, or wild, which grows naturally in the fields, and the cultivated, the stalks of which are smaller, and not so high. For dyeing, the latter is preferred, it abounding more in colouring matter. The more slender the stalk, the more it is valued. When the weld is ripe, it is pulled, dried, and made into bundles, in which state it is used. The yellow communicated to wool by weld has little permanency, if the wool be not previously prepared by some mordant. For this purpose alum and tartar are used, by means of which this plant gives a very pure yellow, which has the advantage of being permanent. For the boiling, which is conducted in the common way, Hellot directs four ounces of alum to every pound of wool, and only one ounce of tartar; many dyers, however, use half as much tartar as alum. Tartar renders the colour paler, but more lively. For the welding, that is for the dyeing with weld, the plant is boiled in a fresh bath, inclosing it in a bag of thin linen, and keeping it from rising to the top by means of a heavy wooden cross. Some dyers boil it till it sinks to the bottom of the copper, and then let a cross down upon it; others, when it is boiled, take it out with a rake, and throw it away. Hellot directs five or six pounds of weld for every pound of cloth; but dyers seldom use so much, contenting themselves with three or four pounds, or even much less. To dye silk plain yellow, in general no other ingredient than weld is used. The silk ought to be scoured in the proportion of twenty pounds of soap to the hundred, and afterward alumed and refreshed, that is, washed after the aluming. A bath is prepared with two pounds of weld for each pound of silk, which after a quarter of an hour's boiling is to be passed through a sieve or cloth into a vat. When it is of such a temperature as the hand can bear, the silk is put in, and turned till the colour is become uniform; during this operation the weld is boiled a second time in fresh water; about half of the first bath is taken out, and its place supplied by a fresh decoction. This fresh bath may be used a little hotter than the former: too great a degree of heat, however, must be avoided, that no part of the colour already fixed may be dissolved; it is to be turned as before, and in the meantime a quantity of the ashes of wine-lees is to be dissolved in a part of the second decoction; the silk is to be taken out of the bath, that more or less of this solution may be put in, according to the shade required. After it has been turned a few times, a hank is wrung with the pin, that it may be seen whether the colour be sufficiently full, and have the proper gold cast; if it should not, a little more of the alkaline solution is added, the effect of which is to give the colour a gold cast, and to render it deeper. In this way the process is to be continued, until the silk has attained the desired shade; the alkaline solution may also be added along with a second decoction of the weld, always taking care that the bath is not too hot. If we wish to produce yellows with more of a gold or jonquille colour, a quantity of annatto proportioned to the shade required must be added to the bath along with the alkali. A water-colour, called weld-yellow, is much used by paper-hanging manufacturers. This is the colouring matter of weld precipitated with an earthy base. The following is given in the Philosophical Magazine, as a method of preparing it very fine:—Into a copper vessel put four pounds of fine washed whiting, and as much soft water, and boil them together, stirring them with a deal stick, till the whole forms a smooth mixture; then add gradually twelve ounces of powdered alum, still stirring, till the effervescence ceases, and the whole is well mixed. Into another copper put any quantity of weld, with the roots uppermost, pour in soft water enough to cover every part containing seed; let it boil, but not more than a quarter of an hour

take out the weld, and set it to drain, and pass the whole of the liquor through flannel. To the hot mixture of earth and water add as much of this decoction as will produce a good colour, keep it on the fire till it boils, and then pour out into a deal or earthen vessel. The next day the liquor may be decanted, and the colour dried on chalk.

WERNERITE. Foliated Scapolite.

WHEAT.—See *Bread, Gluten, Starch.*

WHET-SLATE. Colour greenish-grey; feebly glimmering; fracture slaty in the large; splintery in the small; feels rather greasy; specific gravity 2·722. Very fine varieties are brought from Turkey, called Hone-stones. It is used for sharpening steel instruments.

WHEY. The fluid part of milk which remains after the curd has been separated.—See *Milk*. It contains a saccharine matter, some butter, and a small portion of cheese.

WHISKY. Dilute alcohol, which see.

WHITE COPPER.—See *Tutenag.*

WHITE SPANISH, and WHITE LEAD.—See *Ceruse.*

WHITING. Chalk cleared of its grosser impurities, then ground in a mill, and made up into small loaves, is sold under the name of whiting.

WINE. Chemists give the name of wine in general to all liquors that have become spirituous by fermentation. Thus cider, beer, hydromel or mead, and other similar liquors, are wines. The principles and theory of the fermentation which produces these liquors are essentially the same. The more general principles we have explained under the article *Fermentation*. All those nutritive, vegetable, and animal matters which contain sugar ready formed, are susceptible of the spirituous fermentation. Thus, wine may be made of all the juices of plants, the sap of trees, the infusions and decoctions of farinaceous vegetables, the milk of frugiverous animals; and lastly, it may be made of all ripe succulent fruits; but all these substances are not equally proper to be changed into a good and generous wine. As the production of alcohol is the result of the spirituous fermentation, that wine may be considered as essentially the best, which contains most alcohol. But of all substances susceptible of the spirituous fermentation, none is capable of being converted into so good wine, as the juice of the grapes of France, or of other countries that are nearly of the same latitude, or in the same temperature. The grapes of hotter countries, and even those of the southern provinces of France, do indeed furnish wines that have a more agreeable, that is more of a saccharine taste; but these wines, though they are sufficiently strong, are not so spirituous as those of the provinces near the middle of France; at least, from these latter wines the best vinegar and brandy are made. As an example, therefore, of spirituous fermentation in general, we shall describe the method of making wine from the juice of the grapes of France. This juice, when newly expressed, and before it has begun to ferment, is called must, and in common language, sweet wine. It is turbid, has an agreeable and very saccharine taste. It is very laxative, and when drunk too freely, or by persons disposed to diarrhœas, it is apt to occasion these disorders. Its consistence is somewhat less fluid than that of water, and it becomes almost of a pitchy thickness when dried. When the must is pressed from the grapes, and put into a proper vessel and place, with a temperature between fifty-five and sixty degrees, very sensible effects are produced in it, in a shorter or longer time, according to the nature of the liquor, and the exposure of the place. It then swells, and is so rarified, that it frequently overflows the vessel containing it, if this be nearly full. An intestine motion is excited among its parts, accompanied with a small hissing noise and evident ebullition. The bubbles rise to the surface, and at the same time is disengaged a quantity of carbonic acid of such purity, and so dangerous, that it is capable of killing, instantly, men and animals exposed to it in a place where the air is not renewed. The skins, stones, and other grosser matters of the grapes, are buoyed up by the particles of disengaged air that adhere to their surface, are variously agitated, and are raised in form of a

scum or soft and spongy crust, that covers the whole liquor. During the fermentation, this crust is frequently raised and broken by the air disengaged from the liquor, which forces its way through it; afterwards the crust subsides, and becomes entire as before. These effects continue while the fermentation is brisk, and at last gradually ceases: then the crust, being no longer supported, falls in pieces to the bottom of the liquor. At this time, if we would have a strong and generous wine, all sensible fermentation must be stopped. This is done by putting the wine into close vessels, and carrying these into a cellar or other cool place. After this first operation, an interval of repose takes place, as is indicated by the cessation of the sensible effects of the spirituous fermentation; and thus enables us to preserve a liquor no less agreeable in its taste, than useful for its reviving and nutritive qualities when drank moderately. If we examine the wine produced by this first fermentation, we shall find, that it differs entirely and essentially from the juice of grapes before fermentation. Its sweet and saccharine taste is changed into one that is very different, though still agreeable, and somewhat spirituous and piquant. It has not the laxative quality of must, but affects the head, and occasions, as is well known, drunkenness. Lastly, if it be distilled, it yields, instead of the insipid water obtained from must by distillation with the heat of boiling water, a volatile, spirituous, and inflammable liquor called spirit of wine or alcohol. This spirit is consequently a new being, produced by the kind of fermentation called the vinous or spirituous. See *Alcohol*. When any liquor undergoes the spirituous fermentation, all its parts seem not to ferment at the same time, otherwise the fermentation would probably be very quickly completed, and the appearances would be much more striking. Hence, in a liquor much disposed to fermentation, this motion is more quick and simultaneous than in another liquor less disposed. Experience has shown, that a wine, the fermentation of which is very slow and tedious, is never good or very spirituous; and therefore when the weather is too cold the fermentation is usually accelerated by heating the place in which the wine is made. A proposal has been made by a person very intelligent in economical affairs, to apply a greater than the usual heat to accelerate the fermentation of the wine, in those years in which grapes have not been sufficiently ripened, and when the juice is not sufficiently disposed to fermentation. A too hasty and violent fermentation is, perhaps, also hurtful, from the dissipation and loss of some of the spirit; but of this we are not certain. However, we may distinguish in the ordinary method of making wines of grapes, two periods in the fermentation, the first of which lasts during the appearance of the sensible effects above mentioned, in which the greatest number of fermentable particles ferment. After this first effort of fermentation these effects sensibly diminish, and ought to be stopped, for reasons hereafter to be mentioned. The fermentative motion of the liquor then ceases. The heterogeneous parts that were suspended in the wines by this motion, and render it muddy, are separated, and form a sediment called the lees; after which the wine becomes clear; but though the operation is then considered as finished, and the fermentation apparently ceases, it does not really cease; and it ought to be continued in some degree if we would have good wine. In this new wine a part of the liquor probably remains, that has not fermented, and which afterwards ferments, but so very slowly, that none of the sensible effects produced in the first fermentation are here perceived. The fermentation, therefore, still continues in the wine during a longer or shorter time, although in an imperceptible manner; and this is the second period of the spirituous fermentation, which may be called the imperceptible fermentation. We may easily perceive, that the effect of this imperceptible fermentation is the gradual increase of the quantity of alcohol. It has also another effect no less advantageous, namely, the separation of the acid salt called tartar, from the wine. This matter is therefore a second sediment that is formed in the wine, and adheres to the sides of the containing vessels. As the taste of tartar is harsh and disagreeable, it

is evident that the wine, which, by means of the insensible fermentation, has acquired more alcohol, and has disengaged itself of the greater part of its tartar, ought to be much better and more agreeable; and for this reason, chiefly old wine is universally preferable to new wine. But insensible fermentation can only ripen and meliorate the wine, if the sensible fermentation have regularly proceeded, and been stopped in due time. We know, certainly, that if a sufficient time have not been allowed for the first period of the fermentation, the unfermented matter that remains, being in too large a quantity, will then ferment in the bottles, or close vessels in which the wine is put, and will occasion effects so much more sensible, as the first fermentation shall have been sooner interrupted: hence, these wines are always turbid, emit bubbles, and sometimes break the bottles, from the large quantity of air disengaged during the fermentation. We have an instance of these effects in the wine of Champagne, and in others of the same kind. The sensible fermentation of these wines is interrupted, or rather suppressed, that they may have this sparkling quality. It is well known, that these wines make the corks fly out of the bottles; that they sparkle and froth when they are poured into glasses; and lastly, that they have a taste much more lively and more piquant than wines that do not sparkle: but this sparkling quality, and all the effects depending on it, are only caused by a considerable quantity of carbonic acid gas, which is disengaged during the confined fermentation, that the wine has undergone in close vessels. This air not having an opportunity of escaping, and of being dissipated as fast as it is disengaged, and being interposed betwixt all the parts of the wine, combines, in some measure, with them, and adheres in the same manner as it does to certain mineral waters, in which it produces nearly the same effects. When this air is entirely disengaged from these wines, they no longer sparkle, they lose their piquancy of taste, become mild, and even almost insipid. Such are the qualities that wine acquires in time, when its first fermentation has not continued sufficiently long. These qualities are given purposely to certain kinds of wine, to indulge taste or caprice; but such wines are supposed to be unfit for daily use. Wines for daily use ought to have undergone so completely the sensible fermentation, that the succeeding fermentation shall be insensible, or at least exceedingly little perceived. Wine, in which the first fermentation has been too far advanced, is liable to worse inconveniences than that in which the first fermentation has been too quickly suppressed; for every fermentable liquor is, from its nature, in a continual intestine motion, more or less strong, according to circumstances, from the first instant of the spirituous fermentation, till it is completely purified. Hence, from the time of the completion of the spirituous fermentation, or even before, the wine begins to undergo the acid or acetous fermentation. This acid fermentation is very slow and insensible when the wine is included in very close vessels, and in a cool place; but it gradually advances, so that in a certain time the wine, instead of being improved, becomes at last sour. This evil cannot be remedied; because the fermentation may advance, but cannot be reverted. Wine-merchants, therefore, when their wines become sour, can only conceal or absorb this acidity by certain substances, as by alkalis and absorbent earths. But these substances give to wine a dark greenish colour, and a taste which, though not acid, is somewhat disagreeable. Besides, calcareous earths accelerate considerably the total destruction and putrefaction of the wine. Oxides of lead, having the property of forming with the acid of vinegar, a salt of an agreeable saccharine taste, which does not alter the colour of the wine, and which, besides, has the advantage of stopping fermentation and putrefaction, might be very well employed to remedy the acidity of wine, if lead and all its preparations were not pernicious to health, as they occasion most terrible colics, and even death, when taken internally. We cannot believe that any wine-merchant, knowing the evil consequences of lead, should, for the sake of gain, employ it for the purpose mentioned; but if there be any such persons, they must be considered as the poisoners

and murderers of the public. At Alicant, where very sweet wines are made, it is the practice to mix a little lime with the grapes before they are pressed. This, however, can only neutralize the acid already existing in the grape. If wine contain litharge, or any other oxide of lead, it may be discovered by evaporating some pints of it to dryness, and melting the residuum in a crucible, at the bottom of which a small button of lead may be found after the fusion: but an easier and more expeditious proof is by pouring into the wine some liquid sulphuret. If the precipitate occasioned by this addition of the sulphuret be white, or only coloured by the wine, we may know that no lead is contained in it; but if the precipitate be dark coloured, brown, or blackish, we may conclude that it contains lead or iron. The only substances that cannot absorb or destroy, but cover and render supportable the sharpness of wine, without any inconvenience, are sugar, honey, and other saccharine alimentary matters; but they can succeed only when the wine is very little acid, and when an exceeding small quantity only of these substances is sufficient to produce the desired effect; otherwise the wine would have a sweetish, tart, and not agreeable taste. From what is here said concerning the acescency of wine, we may conclude, that when this accident happens, it cannot, by any good method, be remedied, and that nothing remains to be done with sour wine but to sell it to vinegar-makers, as all honest wine-merchants do. The must of the grape contains a notable proportion of tartar, which our currant and gooseberry juices do not. The wines of Spain are of two descriptions, namely, white and red, and are, for the most part, excellent. The greatest quantities are made in the southern parts of the kingdom, and the sale is very extensive, especially among the English and Dutch. The wines of the Canaries, although not actually Spanish, are to be met with in most of the ports of Spain, and are usually classed with the wines of that country. Although the whole of the Canaries produce excellent wines, the preference is given to those of Parma and Teneriffe. When the vintage proves favourable, Teneriffe annually makes up about 30,000 pipes of Vidonia, or as it is sometimes denominated bastard Madeira, from the similarity of its flavor and appearance to the dry wine of the last mentioned island. Teneriffe also produces a sweet wine, which is nearly similar to Malmsey Madeira. The wine of Chacoli in Biscay, is not of a first rate quality. In order to produce this wine, the Biscayans ingraft five or six different vines upon the same stalk. Most parts of Biscay abound in these vines, which border the high roads, generally growing to the height of about three or four feet. The wine in Biscay is sold at a certain price, as regulated by the police, and until the whole produce of the vintage is disposed of, no foreign wine is permitted to be brought into the province. Hence it happens that the sole study of the proprietors of vineyards, is to collect a large quantity of wine, without attending to quality or flavor, and consequently, Chacoli has become proverbially despicable in Spain. Indeed, the grapes are not allowed to arrive at a state of maturity, but are gathered and squeezed, while sour, and are nearly devoid of substance; but if the juice were allowed to collect and meliorate in the grape, if the green fruit were not mingled with the ripe, if the wines were made with the same care as those of other provinces, this wine would prove equal in every respect (except that of seniority) to the French Champaign, which, of its kind, stands at present unrivalled. The wine of Gudas in Castile, is made from cherries, and is a species of ratafia. Foucal wine, which takes its name from a village near Madrid, is of a good quality, but is only reckoned ordinary The wines of Val de Penas, Cuidad Real, Ribadaria, and Rioxa, and those called La Mancha, are very good, and except in regard to different degrees of colour, are similar in every respect. The best wines of Arragon are those denominated Garnachas, from the species of grape which produces them; the best of all is a red wine named Hospital; it is excellent as to flavor and strength. Caninea, called likewise white Garnachas, is very fine, and is much esteemed. The wines of Peralta, Tu-

dela, Tâfalla, and Arandillo, in Navarre, are nearly alike, and are excellent both as to flavor and quality. That of Peralta is well known under the title of Rancio, which it receives when old enough to merit that distinction. To these may be added the wine of Huesca, which is very good. The wines of Xeres, better known under the name of Sherry, are made at the town of that name in the province of Andalusia. They are not only dry, but sweet; the dry, however, are the most esteemed, more particularly, when they present a pale straw colour. Many who are in the habit of tasting Sherry, have doubtless perceived that there is something in its flavor which partakes of the taste of leather; this is owing to the custom of bringing the wines down the country in large leathern vessels, or, as the Spaniards call them, boots, whence we derive our term butts, which we bestow upon the casks wherein we receive the wines. In Andalusia are made sweet and dry wines, called Pagarete and San Lucar, and the strong well known red wine, denominated Tinto Rota, or Tent, which is an excellent stomachic. The Montillo is a dry wine. The territory of Xeres, alone, annually produces above 60,000 pipes of wine. In the province of Grenada is made the celebrated wine called Mountain or Malaga. It is dry and sweet, both red and white. It is truly a delicious wine, and is much esteemed. The sweet Mountain is the most sought after, and is usually employed as a dessert wine. Grenada produces Peroximenes or Pedro Ximenes, which is a very fine flavored full-bodied wine. There is also a kind of Malmsey made in this province, which is exquisite; but that of Maravella is only an ordinary wine. In Valentia is found the Tinto Alicante, a wine much used in France, It is sweet when new, but grows thick and ropy as it becomes aged; it is a good stomachic. The Benicarlo wine is red, dry, and thick; it is often palmed upon the public by wine dealers, as Port wine; to which it is very inferior, both in quality and price. An imposition of this sort is to be avoided, by observing whether the wine offered have a ruby colour instead of a deep black; a generous flavor and not that harshness which immediately offends a good palate: if not, it assuredly cannot be Port wine. The wine called Siches and that called Garnache, both made in Catalonia, are exquisite. In the same province are made Tinto de las Montanas, or Mountain Tent, and Mataro wine; both of which are sweet, thick, ropy, and unwholesome. The latter is often sold by irreputable traders, to private families, as Tent. It is almost needless to observe that the wine called Port, of which such vast quantities are consumed in Great Britain, is the produce of Portugal. The vines, whence it is made, grow upon the banks of the Douro, about fourteen or fifteen leagues from Oporto, and occupy a space about six leagues in length, and two leagues in breadth. These vineyards produce between 60 and 70,000 pipes of Port, and there are others which yield nearly 6,000 pipes annually. The vine whence we derive our Port, originally grew in Burgundy, but the climate of Portugal being widely different from that of Burgundy, has caused such an alteration in the grape, that no two wines are more unlike, than those which are the produce of the above-mentioned territories. The wines of Portugal, like those of Biscay, are only sold at the prices annually regulated by the government. As soon as the prices are promulgated, the factory and individuals send in their names to the proprietors of the wines; the whole of the Port wine is shipped at Oporto. The brandy of Spain constitutes a considerable article of commerce; it is very inferior to the brandy of France, and is principally used in making up Spanish and Portuguese wines. The brandy of Portugal is nearly the same as that of Spain, and very little of it is exported. Notwithstanding the great natural produce of wines, various attempts have been made, and with success, at a synthetical preparation of this beverage. It is to be feared, that this practice is sometimes carried on, without regard either to science or humanity. Indeed, there are many compounds sold in London and elsewhere, intended to imitate port and other wines, which agree with them in no character save in

colour and astringency; and these, it is known, are given to them by the most pernicious ingredients. But French, and other chemists, have really produced wines which possessed all the agreeable properties of those produced from grapes. This was done by first analysing the wine to be imitated, and then, by apportioning the quantities of the several ingredients which existed in the wine, naturally. In this way, Fabroni made wine, from 864lbs. of sugar, 24lbs. of gum-arabic, 24lbs. of tartar, three pounds of tartareous acid, 36lbs. of gluten of wheat, and 1728 quarts of water. Parmentier made a good Muscadine wine from 216lbs. of sugar, nine pounds of crystals of tartar, 72lbs. of elder flowers, and 307lbs. of water. The colonists in the West Indies, prepare a wine from 250lbs. of sugar, two barrels of water, and four pounds of yeast, this wine is coloured with litmus, and scented with some essential oil. In addition to these synthetical preparations, it may be observed, that others of an analogous, but of a more surprising nature, have recently been effected. Kirchoff, a Russian chemist, discovered that starch may be converted into sugar, possessing all the properties of sugar from grapes, by mixing it with about four times its weight of water, and about one hundredth part of its weight of sulphuric acid. This discovery was confirmed by Saussure, who ascertained that 100 parts of starch became 110·14 parts, when converted into sugar. The same subject being successfully resumed by M. Braconnot, he discovered the important fact, that a sugar, similar to that of grapes, may be obtained by means of sulphuric acid, from the sawings of wood, old linen, and paper. In this operation, a certain quantity of these substances is treated with sulphuric acid, concentrated by cold. The mass appears to be carbonised, but this appearance arises from a stratum of black powder which covers it; and which, when removed by washing, is converted into a true gum, resembling gum-arabic. This gum is separated from the sulphuric acid, in excess, by means of carbonate of lime, and it remains in the liquor. By afterwards treating this gum with sulphuric acids diluted with water, it is converted into true sugar, the quantity of which is greater than that of the sawings of wood, or the linen, employed. In addition to this sugar, which form almost the whole of the mass, M. Braconnot obtained another substance, which he called the *vegeto-sulphuric acid*. The sugar, in question, was of the consistency of syrup; at the end of twenty-four hours it began to crystallize, and some days after, the whole was condensed into a single mass of crystallized sugar, which was pressed strongly between several folds of old cloth; crystallized a second time, this sugar was passably pure; but treated with animal charcoal, it became of a shining whiteness. The crystals were in spherical groups, which appear to be formed by the union of small diverging and unequal plates. They are fusible at the temperature of boiling water. The sugar is of a fresh and agreeable flavour, producing in the mouth a slight sensation of acidity. Mingled in a proper quantity of water, set in fermentation, and hopped according to the method of brewers, the syrup abovementioned, furnishes a beer which is light, brisk, strong, and of an agreeable savour. After having ascertained that all ligneous matter, such as wood, bark, straw, hemp, &c. may be transformed into gum, and into sugar, by the sulphuric acid, M. Braconnot extended his researches to the parts of animals, and he began with gelatine, as obtained from the skin, membranes, tendons, &c. of animals. He found, that gelatine may be converted by sulphuric acid into a crystallizable sugar *sui generis*, which probably does not exist in nature. It crystallizes more readily than that from the cane. It is less fusible, and it contains azote. Its sweetness is nearly equal to that of the sugar of grapes. Its solubility in water is not greater than that of sugar of milk, with which it has, at first sight, some analogies. By slow evaporation, it yields crystals as hard as sugar-candy, and in the form of flat prisms or tables grouped together. He also found, that the sugar of gelatine combines intimately with the nitric acid (with sensible decomposition, and even without the

aid of heat), and then forms a new acid, to which he has given the name of the *nitro-saccharic*.

WITHERITE. Carbonate of barytes.—See *Heavy Spar*.

WOAD, Isatis, Glastum, is a plant which grows wild in some parts of France, and on the coasts of the Baltic Sea; the wild woad, and that which is cultivated for the use of the dyers, appears to be the same species of plant. The preparation of woad for dyeing, as practised in France, is minutely described by Astruc, in his Memoirs for a Natural History of Languedoc. The plant puts forth at first five or six upright leaves about a foot long and six inches broad; when these hang downwards, and turn yellow, they are fit for gathering; five crops are gathered in one year. The leaves are carried directly to a mill, much resembling the oil or tan mills, and ground into a smooth paste. If this process were deferred for some time, they would putrify, and send forth an insupportable stench. The paste is laid in heaps pressed close and smooth, and the blackish crust which forms on the outside re-united if it happens to crack; if this were neglected, little worms would be produced in the crack, and the woad would loose part of its strength. After lying for fifteen days, the heaps are opened, the crust rubbed and mixed with the inside, and the matter formed into oval balls, which are pressed close and solid in wooden moulds. These are dried upon hurdles: in the sun they turn black on the outside, in a close place yellowish, especially if the weather be rainy. The dealers in this commodity prefer the first though it is said the workmen find no considerable difference between the two. The good balls are distinguished by their being weighty, of a pretty agreeable smell, and when rubbed, of a violet colour within. For the use of the dyer these balls require a farther preparation; they are beaten with wooden mallets, on a brick or stone floor, into a gross powder, which is heaped up in the middle of the room to the height of four feet, a space being left for passing round the sides. The powder moistened with water ferments, grows hot, and throws out a thick fœtid fume. It is shovelled backward and forward, and moistened every day for twelve days; after which it is stirred less frequently, without watering, and at length made into a heap for the dyer. The powder thus prepared gives only brownish tinctures of different shades to water, to alcohol, to ammonia, and to fixed alkaline lixivia; rubbed on paper it communicates a green stain. On diluting the powder with boiling water, and after standing for some hours in a close vessel, adding about one-twentieth its weight of lime newly slaked, digesting in a gentle warmth, and stirring the whole together every three or four hours a new fermentation begins; a blue froth rises to the surface, and the liquor though it appears itself of a reddish colour, dyes woollen of a green; which, like the green from indigo, changes in the air to a blue. This is one of the nicest processes in the art of dyeing, and does not well succeed in the way of a small experiment.

WODANIUM. A new metal recently supposed to be discovered by Lampadius in the mineral called Woodan pyrites. It has since been found to have been a mistake.

WOOD, (OPAL).—See *Opal*

WOOD, (ROCK). The ligniform asbetus.

WOODY FIBRE, is procured from the wood, bark, leaves, or flowers of trees, by exposing them to the repeated action of boiling water and boiling alcohol. It is the insoluble matter that remains, and is the basis of the solid organized parts of plants. There are as many varieties of woody fibre as there are plants and organs of plants; but they are all distinguished by their fibrous texture, and their insolubility. Woody fibre burns with a yellow flame, and produces water and carbonic acid in burning. When it is distilled in close vessels, it yields a considerable residuum of charcoal. It is from woody fibre, indeed, that charcoal is procured for the purposes of life. M. Gay Lussac and Thenard have concluded, from their experiments on wood of the oak and the beech, that 100 parts of the first contain,

Of carbon	-	52·53
— oxygen	-	41·78
— hydrogen	-	5·69

and 100 parts of the second.

Of carbon	-	51·45

Of oxygen	42·73
— hydrogen -	5·82

Supposing woody fibre to be a definite compound, these estimations lead to the conclusion, that it consists of 5 proportions of carbon, 3 of oxygen, and 6 of hydrogen; or 57 carbon, 45 oxygen, and 6 hydrogen. It will be unnecessary to speak of the applications of woody fibre. The different uses of the woods, cotton, linen, the barks of trees, are sufficiently known. Woody fibre appears to be an indigestible substance.

WOOTZ. The metal extracted from some kind of iron ore in the East Indies, apparently of good quality. It contains more carbon than steel, and less than cast iron, but from want of skill in the management is far from homogeneous.—*Phil. Trans.*

WORT. See *Beer, Distillation, and Fermentation.*

Y.

YANOLITE. Axinite.

YEAST, is the barm or froth which rises in beer, and other malt liquors, during a state of fermentation. When thrown up by one quantity of malt or vinous liquid, it may be preserved to be put into another at a future period, on which it will exert a similar fermentative action. Yeast is likewise used in the making of bread, which without such an addition would be heavy and unwholesome. It has a vinous, sour odour, a bitter taste, arising from the hops in the malt liquor, and it reddens the vegetable blues. When it is filtered, a matter remains which possesses properties similar to vegetable gluten; by this separation the yeast loses the property of exciting fermentation, but recovers it again when the gluten is added. The addition of yeast to any vegetable substance, containing saccharine matter, excites fermentation by generating a quantity of carbonic acid gas. This very useful substance cannot be always procured conveniently from malt liquor, for baking and brewing; the following methods will be found useful for its extemporaneous preparation. Mix two quarts of soft water with wheat flour, to the consistence of thick gruel; boil it gently for half an hour, and when almost cold, stir into it half a pound of sugar and four spoonfuls of good yeast. Put the whole into a large jug, or earthen vessel, with a narrow top, and place it before the fire, so that it may, by a moderate heat, ferment. The fermentation will throw up a thin liquor, which pour off and throw away; keep the remainder for use (in a cool place), in a bottle or jug tied over. The same quantity of this, as of common yeast, will suffice to bake or brew with. Four spoonfuls of this yeast will make a fresh quantity as before, and the stock may be always kept up by fermenting the new with the remainder of the former quantity. Another method is as follows:—Take six quarts of soft water and two handfuls of wheaten meal or barley; stir the latter in the water before the mixture is placed over the fire, where it must boil till two-thirds are evaporated. When this decoction becomes cool, incorporate with it, by means of a whisk, two drachms of salt of tartar, and one drachm of cream of tartar, previously mixed. The whole should now be kept in a warm place. Thus, a very strong yeast for brewing, distilling, and baking, may be obtained. For the last-mentioned purpose, however, it ought to be diluted with pure water, and passed through a sieve, before it is kneaded with the dough, in order to deprive it of its alkaline taste. In countries where yeast is scarce, it is a common practice to twist hazel twigs so as to be full of chinks, and then to steep them in ale-yeast during fermentation. The twigs are then hung up to dry, and at the next brewing they are put into the wort instead of yeast. In Italy the chips are frequently put into turbid wine, for the purpose of clearing it; this is effected in about twenty-four hours.

Preparation of Yeast Cakes.

Mr. Cobbett has lately published an excellent method for preparing artificial yeast. In Long Island, America, the people are in the habit of making yeast cakes once a-year. These are dissolved and mixed with the dough, which it raises in such a manner as to

form it into most excellent bread. The following is the method in which these cakes are made:—Rub three ounces of hops, so as to separate them, and then put them into a gallon of boiling water, where they are to boil for half an hour. Now strain the liquor through a fine sieve into an earthen vessel, and while it is hot, put in three pounds and a half of rye flour, stirring the liquor well and quickly, as the flour is put in. When it has become as cool as wort for brewing, add half a pint of good yeast. On the following day, whilst the mixture is fermenting or working, stir well into it seven pounds of Indian corn meal; this will render the whole mass stiff like dough; this dough is to be well kneaded and rolled out into cakes about a third of an inch in thickness. These cakes are to be cut out into large disks, or lozenges, or any other shape, by an inverted tumbler or other instrument; and being placed on a sheet of tinned iron, or on a piece of board, are to be dried by the heat of the sun. If care be taken that they are frequently turned, and that they receive no wet or moisture, they will become as hard as ship biscuit, and may be kept in a bag or box, which is to be hung up, or kept in an airy and perfectly dry situation. When bread is to be made, two cakes of the above-mentioned thickness, and about three inches in diameter, are to be broken and put into hot water, where they are to remain all night,—the vessel standing near the fire. In the morning they will be entirely dissolved, and then the mixture is to be employed in setting the sponge in the same way that beer yeast is used. In making a further supply for the next year, beer, or ale yeast may be used as before; but this is not necessary where a cake of the old stock remains, this acting on the new mixture in precisely the same way. If the dry cakes were reduced to powder in a mortar, the same results would take place, with perhaps more convenience, and less loss of time. Regarding the employment of Indian meal, it is used because it is of a less adhesive nature than wheaten flour; but where Indian meal cannot be easily procured, white pea-meal, or even barley-meal, will answer the purpose equally well. The principal art or requisite in making yeast cakes, consists in drying them quickly and well, and in preventing them from coming in contact with the least particle of moisture, until they are used.

YELLOW EARTH. Colour ochre-yellow; soils; slightly soft; adheres to the tongue; feels rather greasy; specific gravity 2·24; constituents, silica 92, alumina 2, lime 3, iron 3. When burnt, it is sold by the Dutch under the name of English red. It was used as a yellow paint by the ancients.

YENITE. Lievrite.

YOLK, is an animal soap, the natural defence of the wool of sheep. In washing sheep, the use of water containing carbonate of lime should be avoided; for this substance decomposes the yolk of the wool, and wool often washed in calcareous water, becomes rough and more brittle. The finest wool, such as that of the Spanish and Saxon sheep, is most abundant in yolk. M. Vauquelin has analysed several different species of yolk, and has found the principal part of all of them a soap, with a basis of potassa (*i. e.* a compound of oily matter and potassa), with a little oily matter in excess. He has found in them, likewise, a notable quantity of acetate of potassa, and minute quantities of carbonate of potassa and muriate of potassa, and a peculiar odorous animal matter. M. Vauquelin states, that he found some specimens of wool lose as much as 45 per cent. in being deprived of their yolk; and the smallest loss in his experiments was 35 per cent. The yolk is most useful to the wool on the back of the sheep in cold and wet seasons; probably the application of a little soap of potassa, with excess of grease to the sheep brought from warmer climates in our winter, that is, increasing their yolk artificially, might be useful in cases where the fineness of the wool is of great importance. Sir H. Davy, in his lectures, says, "a mixture of this kind is more conformable to nature than that ingeniously adopted by Mr. Bakewell; but at the time his labours commenced, the chemical nature of the yolk was unknown." On this Mr. Bakewell remarks:—"As the late Mr. Bakewell, of Dishley, the distinguished improver of 'live stock,' never adopted

any mixture whatever, I presume sir H. Davy must refer to the mode I recommended of applying an ointment made of butter and a small quantity of tar melted together, as a defence against the injurious effects of calcareous soils. A similar mixture, but with more tar, had long been employed by the northern farmers as a defence against the climate: when judiciously applied, it is now found to be a great improvement to the soft quality of the wool. This is not a matter of theory, but an acknowledged and incontrovertible fact, well known to all the Yorkshire cloth manufacturers. The writer of the 'Observation' was acquainted with the experiments of Vauquelin on the yolk in wool; but he did not recommend the mixture mentioned by Mr. Luccock and sir H. Davy, because it is liable to be washed off by the first heavy rains. At the last annual agricultural dinner of lord Somerville (1813), his lordship, in giving the prize to Mr. J. F. Smith, for the best piece of cloth made from English wool, addressed the company as follows:—"Gentlemen, I beg leave to remark, that the piece of cloth for which this prize is obtained, was manufactured from Northumberland wool, anointed with the mixture recommended in Mr. Bakewell's Observations on Wool. The arguments he has advanced in defence of this mode of treatment have never been opposed, nor can they ever be overturned.' I trust I shall be excused for quoting this authority in support of a practice which is known to preserve many thousand sheep from perishing every winter in the northern parts of the island, and which might be introduced into the southern counties with equal benefit to the animal and the wool."

YTTRIA. This is a new earth, discovered in 1794, by Prof. Gadolin, in a stone from Ytterby, in Sweden. —See *Gadolinite*. It may be obtained most readily by fusing the gadolinite with two parts of caustic potash, washing the mass with boiling water, and filtering the liquor, which is of a fine green. This liquor is to be evaporated, till no more oxide of manganese falls down from it in a black powder; after which the liquid is to be saturated with nitric acid. At the same time digest the sediment, that was not dissolved, in very dilute nitric acid, which will dissolve the earth with much heat, leaving the silex, and the highly oxided iron, undissolved. Mix the two liquors, evaporate them to dryness, re-dissolve, and filter, which will separate any silex or oxide of iron that may have been left. A few drops of a solution of carbonate of potash will separate any lime that may be present, and a cautious addition of hydrosulphuret of potash will throw down the oxide of manganese that may have been left; but if too much be employed, it will throw down the yttria likewise. Lastly, the yttria is to be precipitated by pure ammonia, well washed, and dried. Yttria is perfectly white when not contaminated with oxide of manganese, from which it is not easily freed. Its specific gravity is 4·842. It has neither taste nor smell. It is infusible alone; but with borax melts into a transparent glass, or opaque white, if the borax were in excess. It is insoluble in water, and in caustic fixed alkalies; but it dissolves in carbonate of ammonia, though it requires five or six times as much as glucine. It is soluble in most of the acids. The oxalic acid, or oxalate of ammonia, forms precipitates in its solutions perfectly resembling the muriate of silver. Prussiate of potash, crystallized and re-dissolved in water, throws it down in white grains; phosphate of soda, in white gelatinous flakes; infusion of galls, in brown flocks. Some chemists are inclined to consider yttria rather as a metallic than as an earthy substance; their reasons are its specific gravity, its forming coloured salts, and its property of oxygenizing muriatic acid after it has undergone a long calcination.—*Crell's Chem. An.*—*Scherer's Journ.*—*Annales de Chimie.*

If yttria be treated with potassium and a powerful application of galvanism, the potassium becomes potash, and the yttria acquires appearances of being a metal We have, therefore, every reason to believe, that yttria consists of an inflammable metallic substance, combined with oxygen. Many of the salts of lime are insoluble in water. In those which dissolve, precipitates are occasioned by phosphate of soda, carbonate of

soda, oxalate of ammonia, tartrate of potash, and ferro prussiate of potash. With the exception of the sweet-tasted sulphate of yttria, the other salts of this earth, in their solubility, resemble salts of lime.

YTTRO-TANTALITE. An ore of tantalum.

YTTRO-CERITE. Yields to the knife. Scratches fluor. Sp. gr. 3·447. Constituents, oxide of cerium 13·15, yttria 14·6, lime 47·77, fluoric acid 24·45.—*Berzelius.*

Z.

ZAFFRE, or SAFFRE, is the residuum of cobalt, after the sulphur, arsenic, and other volatile matters of this mineral have been expelled by calcination. The zaffre that is commonly sold, and which comes from Saxony, is a mixture of oxide of cobalt with some vitrifiable earth. It is of a grey colour, as all the oxides of cobalt are before vitrification.

ZEOLITE. The name of a very extensive mineral genus. Fibrous zeolite, of which there are two kinds, the acicular, or needle zeolite, and common fibrous zeolite. Acicular, or Needle zeolite, the mesotype of Haüy. Brittle. Sp. gr. 2·0 to 2·3. Its constituents are, silica 50·24, alumina 29·3, lime 9·46, water 10. Common fibrous zeolite.—Colour white. Sp. gr. 2·16 to 2·2. Its constituents are, silica 49, alumina 27, soda 17, water 9·5. Mealy zeolite.—Colour white. Its constituents are, silica 60, alumina 15·6, lime 8, oxide of iron 1·8, loss, by exposure to heat, 11·6. Prismatoidal zeolite, or stilbite.—Of this there are two sub-species; the foliated and radiated. 1. Foliated zeolite, the stilbite of Haüy. Colour white, of various shades. Sp. gr. 2· to 2·2. Constituents, silica 52·6, alumina 17·5, lime 9, water 18·5. 2. Radiated zeolite.—Stilbite of Haüy. Colours yellowish-white and greyish-white. Shining, pearly. Sp. gr. 2·14. Constituents, silica 49·96, alumina 20·09, lime 10·95, water 16·5.

ZERO. The commencement of a scale of the thermometer, marked 0. In Fahrenheit's thermometer zero is 32° below freezing point. In Reaumur's thermometer, and in the centigrade thermometer, zero coincides with the freezing point of water.

ZIMOME.—If the gluten of wheat be treated with alcohol, it is reduced by the loss of water and gliadine to one-third of its bulk, which consists of zimome. Zimome is a shapeless mass, rough and destitute of cohesion. It is heavier than water. It is soluble in vinegar and the mineral acids, at a boiling temperature. Zimome is found in various vegetables.

ZINC, is a metal of a bluish-white colour, somewhat brighter than lead, of considerable hardness, and so malleable as not to be broken with the hammer, though it cannot be much extended in this way. It is very easily extended by the rollers of the flatting mill. Its sp. gr. is from 6·9 to 7·2. In a temperature between 210° and 300° of F., it has so much ductility that it can be drawn into wire, as well as laminated, for which a patent has been obtained by Messrs. Hobson and Sylvester, of Sheffield. The zinc thus annealed and wrought retains the malleability it had acquired. When broken by bending, its texture appears as if composed of cubical grains. On account of its imperfect malleability, it is difficult to reduce it into small parts by filing or hammering; but it may be granulated, like the malleable metals, by pouring it, when fused, into cold water; or, if it be heated nearly to melting, it is then sufficiently brittle to be pulverized. It melts long before ignition, at about the 700th degree of Fahrenheit's thermometer; and soon after it becomes red-hot, it burns with a dazzling white flame, of a bluish or yellowish tinge, and is oxidized with such rapidity, that it flies up in the form of white flowers, called the flowers of zinc, or philosophical wool. These are generated so plentifully, that the access of air is soon intercepted, and the combustion ceases, unless the matter be stirred, and a considerable heat kept up. The white oxide of zinc is not volatile, but is driven up merely by the force of the combustion. When it is again urged by a strong heat, it becomes

converted into a clear yellow glass. If zinc be heated in closed vessels, it rises without decomposition. The diluted sulphuric acid dissolves zinc, at the same time that the temperature of the solvent is increased, and much hydrogen escapes, an undissolved residue is left, which has been supposed to consist of plumbago. Proust, however, says, that it is a mixture of arsenic, lead, and copper. As the combination of the sulphuric acid and the oxide proceeds, the temperature diminishes, and the sulphate of zinc, which is more soluble in hot than cold water, begins to separate, and disturb the transparency of the fluid. If more water be added, the salt may be obtained in fine prismatic four-sided crystals. The white vitriol, or copperas, usually sold, is crystallized hastily, in the same manner as loaf-sugar, which on this account it resembles in appearance; it is slightly efflorescent. The white oxide of zinc is soluble in the sulphuric acid, and forms the same salt as is afforded by zinc itself. The hydrogen gas that is extricated from water by the action of sulphuric acid, carries up with it a portion of zinc, which is apparently dissolved in it; but this is deposited spontaneously, at least in part, if not wholly, by standing. It burns with a brighter flame than common hydrogen. Sulphate of zinc is prepared in the large way from some varieties of the native sulphuret. The ore is roasted, wetted with water, and exposed to the air. The sulphur attracts oxygen, and is converted into sulphuric acid; and the metal being at the same time oxidized, combines with the acid. After some time the sulphate is extracted by solution in water, and the solution being evaporated to dryness, the mass is run into moulds. Thus the white vitriol of the shops generally contains a small portion of iron, and sometimes of lead. Sulphurous acid dissolves zinc, and sulphuretted hydrogen is evolved. The solution, by exposure to the air, deposits needly crystals, which, according to Fourcroy and Vauquelin, are sulphuretted sulphate of zinc. By dissolving oxide of zinc in sulphurous acid, the pure sulphate is obtained. This is soluble and crystallizable. Diluted nitric acid combines rapidly with zinc, and produces much heat, at the same time that a large quantity of nitrous air flies off. The solution is very caustic, and affords crystals by evaporation and cooling, which slightly detonate upon hot coals, and leave oxide of zinc behind. This salt is deliquescent. Muriatic acid acts very strongly upon zinc, and disengages much hydrogen; the solution when evaporated does not afford crystals, but becomes gelatinous. By a strong heat it is partly decomposed, a portion of the acid being expelled, and part of the muriate sublimes and condenses in congeries of prisms. Phosphoric acid dissolves zinc. The phosphate does not crystallize, but becomes gelatinous, and may be fused by a strong heat. The concrete phosphoric acid heated with zinc filings, is decomposed. Fluoric acid likewise dissolves zinc. The boracic acid digested with zinc becomes milky; and if a solution of borax be added to a solution of muriate or nitrate of zinc, an insoluble borate of zinc is thrown down. A solution of carbonic acid in water dissolves a small quantity of zinc, and more readily its oxide. If the solution be exposed to the air, a thin iridescent pellicle forms on its surface. The acetic acid readily dissolves zinc, and yields by evaporation crystals of acetate of zinc, forming rhomboidal or hexagonal plates. These are not altered by exposure to the air, are soluble in water, and burn with a blue flame. The succinic acid dissolves zinc with effervescence, and the solution yields long, slender, foliated crystals. Zinc is readily dissolved in benzoic acid, and the solution yields needle-shaped crystals, which are soluble both in water and in alcohol. Heat decomposes them by volatilizing their acid. The oxalic acid attacks zinc with a violent effervescence, and a white powder soon subsides, which is oxalate of zinc. If oxalic acid be dropped into a solution of sulphate, nitrate, or muriate of zinc, the same salt is precipitated; it being scarcely soluble in water unless an excess of acid be present. It contains seventy-five per cent of metal. The tartaric acid likewise dissolves zinc with effervescence, and forms a salt difficult of solution in water. The citric acid attacks zinc with effervescence, and small bril-

liant crystals of citrate of zinc are gradually deposited, which are insoluble in water. Their taste is styptic and metallic, and they are composed of equal parts of the acid and of oxide of zinc. The malic acid dissolves zinc, and affords beautiful crystals by evaporation. Lactic acid acts upon zinc with effervescence, and produces a crystallizable salt. The metallic acids likewise combine with zinc. If arsenic acid be poured on it, an effervescence takes place, arsenical hydrogen gas is emitted, and a black powder falls down, which is arsenic in the metallic state, the zinc having deprived a portion of the arsenic, as well as the water, of its oxygen. If one part of zinc filings and two parts of dry arsenic acid be distilled in a retort, a violent detonation takes place, when the retort becomes red, occasioned by the sudden absorption of the oxygen of the acid by the zinc. The arseniate of zinc may be precipitated by pouring arsenic acid into the solution of acetate of zinc, or by mixing a solution of an alkaline arseniate with that of sulphate of zinc. It is a white powder, insoluble in water. By a similar process, zinc may be combined with the molybdic acid, and with the oxide of tungsten, the tungstic acid of some, with both of which it forms a white insoluble compound; and with the chromic acid, the result of which compound is equally insoluble, but of an orange red colour. Zinc likewise forms some triple salts. Thus, if the white oxide of zinc be boiled in a solution of muriate of ammonia, a considerable portion is dissolved; and though part of the oxide is again deposited as the solution cools, some of it remains combined with the acid and alkali in the solution, and is not precipitable either by pure alkalies, or their carbonates. This triple salt does not crystallize. If the acidulous tartrate of potash be boiled in water with zinc filings, a triple compound will be formed, which is very soluble in water, but not easily crystallized. This, like the preceding, cannot be precipitated from its solution, either by pure or carbonated alkalies. A triple sulphate of zinc and iron may be formed by mixing together the sulphates of iron and of zinc dissolved in water, or by dissolving iron and zinc in dilute sulphuric acid. This salt crystallizes in rhomboids, which nearly resemble the sulphate of zinc in figure, but are of a pale green colour. In taste, and in degree of solubility, it differs little from the sulphate of zinc. It contains a much larger proportion of zinc than of iron. A triple sulphate of zinc and cobalt, as first noticed by Link, may be obtained by digesting zaffre in a solution of sulphate of zinc. On evaporation, large quadrilateral prisms are obtained, which effloresce on exposure to the air. Zinc is precipitated from acids by the soluble earths and the alkalies; the latter re-dissolve the precipitate, if they be added in excess. Zinc decomposes or alters the neutral sulphates in the dry way. When fused with sulphate of potash, it converts that salt into a sulphuret: the zinc at the same time being oxidized, and partly dissolved in the sulphuret. When pulverized zinc is added to fused nitre, or projected together with that salt into a red-hot crucible, a very violent detonation takes place; insomuch that it is necessary for the operator to be careful in using only small quantities, lest the burning matter should be thrown about. The zinc is oxidised, and part of the oxide combines with the alkali, with which it forms a compound soluble in water. Zinc decomposes common salt, and also sal ammoniac, by combining with the muriatic acid. The filings of zinc likewise decompose alum, when boiled in a solution of that salt, probably by combining with its excess of acid. Zinc may be combined with phosphorus, by projecting small pieces of phosphorus on the zinc melted in a crucible, the zinc being covered with a little resin, to prevent its oxidation. Phosphuret of zinc is white, with a shade of bluish grey, has a metallic lustre, and is a little malleable. When zinc and phosphorus are exposed to heat in a retort, a red sublimate rises, and likewise a bluish sublimate, in needly crystals, with a metallic lustre. If zinc and phosphoric acid be heated together, with or without a little charcoal, needly crystals are sublimed, of a silvery-white colour. All these, according to Pelletier, are phosphuretted oxides of zinc. Most of the metallic combinations of zinc have been al-

ready treated of. It forms a brittle compound with antimony: and its effects on manganese, tungsten, and molybdena, have not yet been ascertained.

ZIRCONIA, was first discovered in the jargon of Ceylon, by Klaproth, in 1789, and it has since been found in the jacinth. To obtain it, the stone should be calcined and thrown into cold water, to render it friable, and then powdered in an agate mortar. Mix the powder with nine parts of pure potash, and project the mixture by spoonfuls into a red-hot crucible, taking care that each portion is fused before another is added. Keep the whole in fusion, with an increased heat, for an hour and a half. When cold, break the crucible, separate its contents, powder and boil in water, to dissolve the alkali. Wash the insoluble part; dissolve in muriatic acid; heat the solution, that the silex may fall down, and precipitate the zircon by caustic fixed alkali. Or the zircon may be precipitated by carbonate of soda, and the carbonic acid expelled by heat. Zircon is a fine white powder, without taste or smell, but somewhat harsh to the touch. It is insoluble in water; yet if slowly dried, it coalesces into a semi-transparent yellowish mass, like gum-arabic, which retains one-third its weight of water. It unites with all the acids. It is insoluble in pure alkalis; but the alkaline carbonates dissolve it. Heated with the blow-pipe, it does not melt, but emits a yellowish phosphoric light. Heated in a crucible of charcoal, bedded in charcoal powder, placed in a stone crucible, and exposed to a good forge fire for some hours, it undergoes a pasty fusion, which unites its particles into a grey opaque mass, not truly vitreous, but more resembling porcelain. In this state it is sufficiently hard to strike fire with steel, and scratch glass; and is of the specific gravity of 4·3. There is the same evidence for believing that zirconia is a compound of a metal and oxygen, as that afforded by the action of potassium on the other earths.

ZOISITE, is divided into two kinds, the common and friable.

1. Common zoisite. Colour yellowish grey; glistening and resino-pearly; fracture small-grained, uneven; feebly translucent; as hard as epidote; very easily frangible: specific gravity 3·3. Its constituents are silica 43, alumina 29, lime 21, oxide of iron 3.

2. Friable zoisite. Colour reddish-white, which is spotted with pale peach-blossom red; massive, and in very fine loosely aggregated granular concretions; translucent on the edges; brittle; specific gravity 3·3. Its constituents are, silica 44, alumina 32, lime 20, oxide of iron 2·5.

ZOONATES. Combinations of the zoonic acid with the salifiable bases.

ZOONIC. In the liquid procured by distillation from animal substances, which had been supposed to contain only carbonate of ammonia and an oil, Berthollet imagined that he had discovered a peculiar acid, to which he gave the name of zoonic. Thenard, however, has demonstrated that it is merely acetic acid combined with an animal matter.

ZOOPHYTES. Scarcely any chemical experiments have been published on these interesting subjects, if we except the admirable dissertation by Mr. Hatchett, in the Philosophical Transactions for 1800. From this dissertation, and from a few experiments of Merat-Guillot, we learn, that the hard zoophytes are composed chiefly of three ingredients.

1. An animal substance of the nature of coagulated albumen, varying in consistency; sometimes being gelatinous and almost liquid, at others of the consistency of cartilage.

2. Carbonate of lime.

3. Phosphate of lime.

In some zoophytes the animal matter is very scanty, and phosphate of lime wanting altogether; in others the animal matter is abundant, and the earthy salt pure carbonate of lime; while in others the animal matter is abundant, and the hardening salt a mixture of carbonate of lime and phosphate of lime; and there is a fourth class almost destitute of earthy salts altogether. Thus, there are four classes of zoophytes; the first resemble porcellaneous shells; the second resemble mother-of-pearl shells; the third resemble crusta; and the fourth horn.

1. When the *madrepora virginea* is immersed in diluted nitric acid, it effervesces strongly, and is soon dissolved. A few gelatinous particles

float in the solution, which is otherwise transparent and colourless. Ammonia precipitates nothing; but its carbonate throws down abundance of carbonate of lime. It is composed, then, of carbonate of lime and a little animal matter. The following zoophytes yield nearly the same results:—

Madrepora muricata.
———— labyrinthica.
Millepora cerulea.
———— alcicornis.
Tubipora musica.

2. When the *madrepora ramea* is plunged into weak nitric acid, an effervescence is equally produced; but after all the soluble part is taken up, there remains a membrane which retains completely the original shape of the madrepore. The substance taken up is pure lime. Hence, this madrepore is composed of carbonate of lime, and a membranaceous substance, which, as in mother-of-pearl shells, retains the figure of the madrepore. The following zoophytes yield nearly the same results:—

Madrepora fascicularis.
Millepora cellulosa.
———— fascialis.
———— truncata.
Iris hippuris.

The following substances, analysed by Merat-Guillot, belong to this class from their composition, though it is difficult to say what are the species of zoophytes which were analysed. By *red coral*, he probably meant the *gorgonia nobilis*, though that substance is known, from Hatchett's analysis, to contain also some phosphate:—

	White coral.	Red coral.	Articulated coralline.
Carbonate of lime	50	53·5	49
Animal matter	50	46·5	51
	100	100·0	100

3. When the *madrepora polymorpha* is steeped in weak nitric acid, its shape continues unchanged; there remaining a tough membranaceous substance of a white colour and opaque, filled with a transparent jelly. The acid solution yields a slight precipitate of phosphate of lime, when treated with ammonia, and carbonate of ammonia throws down a copious precipitate of carbonate of lime. It is composed, therefore, of animal substance, partly in the state of jelly, partly in that of membrane, and hardened by carbonate of lime, together with a little phosphate of lime.

Flustra foliacea, treated in the same manner left a finely reticulated membrane, which possessed the properties of coagulated albumen. The solution contained a little phosphate of lime, and yielded abundance of carbonate of lime when treated with the alkaline carbonates. The *corallina opuntia*, treated in the same manner, yielded the same constituents; with this difference, that no phosphate of lime could be detected in the fresh coralline, but the solution of burnt corraline yielded traces of it. The *iris ochracea* exhibits the same phenomena, and is formed of the same constituents. When dissolved in weak nitric acid, its colouring matter falls in the state of a fine red powder, neither soluble in nitric nor muriatic acid, nor changed by them; whereas the tingeing matter of the *tubipora musica* is destroyed by these acids. The branches of this iris are divided by a series of knots. These knots are cartilagineous bodies connected together by a membraneous coat. Within this coat there is a conical cavity filled with the earthy or corraline matter; so that, in the recent state, the branches of the iris are capable of considerable motion, the knots answering the purpose of joints. See *Coral*.

Mr. Hatchett analysed many species of sponges, but found them all similar in their composition. The *spongia cancellata*, *oculata*, *infundibuliformis*, *palmata*, and *officinalis*, may be mentioned as specimens. They consist of gelatine, which they gradually give out to water, and a thin brittle membraneous substance, which possesses the properties of coagulated albumen.

ZUNDERERZ. Tinder ore. An ore of silver.

THE END.

INTRODUCTION.

Chemistry, considered as a science, is only of modern origin. Many of the arts, the processes of which chemistry undertakes to explain, and has greatly improved, were discovered at an early period in history; but they were merely lucky inventions, followed merely as arts, without any knowledge of the principles or properties of matter by which the processes might be illustrated or improved. Much labour must have been bestowed, and many important facts observed and collected, which in future times were to be the foundation of science. The same observation may justly be applied to the labours of the alchemists in the middle ages, who in the ardent pursuit of the Philosopher's Stone and the Elixir of Life, left no process unattempted, no mixture untried, and persevered in their operations with a patience which could have been produced only by the intense anxiety to make the important discovery which they imagined possible, and from which they expected to derive unbounded good.

Some of the arts, in the practice of which the moderns are still very far from perfection, were in use amongst the earliest nations on record. The arts of metallurgy, dying, and pottery, were a very early invention, and most nations, even those in a state of comparative barbarism, in every part of the world, are found to be more or less acquainted with them. Several chemical processes of a difficult and abstruse kind, have, indeed, been exercised by nations in times of very remote antiquity, as we learn from the evidence given of the skill of Tubal Cain, and the dissolution of the Golden Calf by Moses. The art of fermentation, or of making wine, was known in ancient times; as is proved by the intoxication of Noah, there being no inebriating quality in the unfermented juice of the grape. The Egyptians were very early acquainted with the preparation of wine, as is proved by the

tradition of Osiris, or Bacchus, having traversed the globe for the purpose of teaching it to all nations: they were also skilled in the manufacturing of metals, in medicinal chemistry, and in the art of embalming dead bodies, long before the time of Moses; as appears from the mention made of Joseph's cup, and from the physicians being ordered to embalm the body of Jacob. They practised also the arts of dying, and of making coloured glass, at a very early period; as has been gathered, not only from the testimony of Strabo, but from the relics found with their mummies, and from the glass beads with which these mummies are sometimes studded. The late discoveries of Belzoni, also, prove, that in the preparation of colours, the ancient Egyptians were unrivalled; for, on opening some of the royal tombs which had, for ages, been buried under a great depth of sand, the walls were found to be covered by paintings of the most brilliant and permanent hues: indeed, superior to any thing produced in modern times. The far-famed purple of Tyre is another proof of the perfection to which the art of dying had been carried; and their intercourse with the Cornish miners may be considered a probable evidence of a solution of tin being used by the Tyrians for that purpose. Wootz, silk-dying, porcelain, paper, gunpowder, and other manufactures, in China and India, must have been discovered and brought to their present state of perfection at a very early period; for it must be remembered, that in these countries the state of the arts has long been what it is at the present moment. This we learn from their own writings, and from the well-known habits of the Chinese and Indians to produce little or no change in their social and other institutions, after they have once attained the desired end.

In the processes of the arts necessary for the preparation of colours, the Egyptians and the Greeks attained a perfection unknown to modern times. The vivid freshness of the paintings in the tombs of the ancient Egyptians, which have lately been examined, astonishes every beholder; and after several thousand years they appear as if finished but yesterday. The same observation will apply to the paintings on the walls of the houses in the town of Pompeii, near Naples, which for so many centuries was buried under the ashes of Mount Vesuvius.

The fashion of Aaron's garments clearly indicates that the

arts of metallurgy; of dying leather red, and linen blue, purple, and scarlet; also of distinguishing, and engraving precious stones, were practised among the Israelites of old. These arts, they had, doubtless, learned in Egypt, which, at that time, was the emporium of every known science and art.

The Greeks, as described by Homer, do not appear to have made great progress in the arts connected with chemistry. They were unacquainted with iron; their arms and utensils being made of brass. At the period of the greatest glory of the Greeks, their attention does not seem to have been particularly directed to these subjects; and their men of science either occupied themselves with disputes on metaphysical topics, or if they turned their attention to physics, they pursued a similar course, and instead of making researches into the operations of nature, and of investigating by experiment, they preferred to devise theories in the closet, which furnished subjects of dispute. Occasionally, however, we meet with some happy conjectures in their works. Thus Thales supposed water to be a compound body, formed of a highly inflammable principle, and the chief promoter of combustion; which is not very far from what is now known to be the case, water being compounded of oxygen and hydrogen gases, both of them inflammable; and oxygen being the chief supporter of combustion. He also believed *fire* to be the result of the vivid motion of the particles of bodies.

It does not appear that there were any men amongst the more ancient Greeks and Romans who devoted themselves to the study and practice of chemistry; but in the second or third century, there originated a pursuit which occupied the attention of the world, and employed the thoughts and labours of innumerable individuals; and in the middle ages it prevailed to a still greater extent.

The objects of the alchemists were the transmutation of metals into gold, and the discovery of an universal remedy, or *Elixir of Life*: both of which they expected would be accomplished by means of the *Philosopher's Stone*. As they joined enthusiasm with mystery, and promised with boldness what exceeded the steady limits of probability—as they created for their use a symbolic language, and mingled their doctrines with the philosophic and mythologic reveries of all the existing sects and secret societies, they obtained

zealous disciples amongst the lovers of the marvellous, whilst they found powerful enemies in all true philosophers. We find alchemists amongst the Manichæans, the Essenians, the Hermits of Thebes, the Cabalists, the Gymnosophists, the Rosicrucians, and the Illuminati. The jugglers of India, Asia, and Europe, were associated for many ages with the pretended possessors of the Philosopher's Stone; and many princes, in the efforts they made to destroy them, were, perhaps, prompted by alarm for their own safety, rather than by an abhorrence of such errors. Some, however, were actuated by a real love for true philosophy. Dioclesian ordered all the writings relating to the *great work* (as it was termed) to be destroyed; and since the adoption of Christianity, popes and kings have often fulminated their anathemas and proclaimed their decrees against the alchemists, without, however, doing any thing towards curing them of their folly; for when an enthusiastic passion gives energy to the opinions of men, all power is opposed to them in vain.

The credulous part of the people, in what are called the middle ages, seem to have generally believed that the secret of the Philosopher's Stone was possessed by some few, who were waiting only for a favourable epoch for manifesting their power in all its mightiness. Arnold, of Villa-Nova, was said to have converted iron into gold, at Rome; and Raymund Lully to have effected a similar operation before Edward the First, in London, of which it was said that gold nobles were made.

About the beginning of the thirteenth century, many useful and highly valuable discoveries began, however, to be made known Bacon happily described the alchemists as similar to those husbandmen, who in searching for a treasure supposed to be hidden in their land, by turning up and pulverizing the soil, rendered it fertile. In searching for improbabilities they sometimes discovered realities. The most successful amongst them, at the commencement of this epoch, were Albert, in Germany, and Roger (commonly known by his appellation of Friar) Bacon, in England: though these men seem not to have been wholly led away by the visions of their contemporaries, but to have cultivated science in many respects in the most laudable manner. They, especially the latter, seem to have as far exceeded the common standard of learning in the age in which they lived,

as any philosophers who have appeared in any country, either before their time, or since. But, within a hundred and twenty years from the death of Friar Bacon, the nobility and gentry of England had become so infatuated with the notions of alchemy, and had wasted so much of their property in search of the Philosopher's Stone, as to render the interposition of government necessary to restrain their folly. The following act of parliament (which Lord Coke called the shortest he ever met with) was passed 5th of Henry IV. "None from henceforth shall use to multiply gold or silver, or use the craft of multiplication; and if any the same do, he shall incur the pain of felony." It has been suggested, that the reason of passing this act, was not an apprehension lest men should ruin their fortunes by endeavouring to make gold, but a jealousy lest government should be above asking aid of the subject. This act, whatever might be the occasion of passing it, though it gave some obstruction to the public exercise of alchemy, yet did not cure the disposition for it in individuals, nor remove the general credulity; for in the 35th of Henry VI., letters-patent were granted to several people, by which they were permitted to investigate an universal medicine, and to perform the transmutation of metals into real gold and silver, with a non obstante of the forementioned statute, which remained in full force till the year 1689, when being conceived to operate to the discouragement of the melting and refining of metals, it was formally repealed.

The beginning of the sixteenth century was remarkable for a great revolution produced in the European practice of physic, by means of chemistry; for Paracelsus, famous for curing syphilis, the leprosy, and other virulent disorders, by means of mercurial and antimonial preparations, wholly rejected the Galenical pharmacy, and substituted the chemical in its stead. He had a professor's chair given him by the magistracy of Basil, and was the first who read public lectures in medicine and chemistry, and subjected animal and vegetable, as well as mineral substances, to examination by fire.

So great a genius as Paracelsus, could not fail of becoming alike the subject of the extremes of panegyric and satire. He has accordingly been esteemed by some, as a second Esculapius; others have thought that he was possessed of more impudence than merit, and that his reputation was

more owing to the brutal singularity of his conduct, than to the cures he performed. He treated the physicians of his time with the most illiberal insolence, telling them, "that the very down on his bald pate had more knowledge than all their writers; the buckles of his shoes more learning than Galen or Avicenna; and his beard more experience than all their universities." He revived the extravagant doctrine of Raymund Lully, concerning an universal medicine, and untimely sunk into his grave at the age of forty-seven, whilst he boasted himself to be in possession of secrets, able to prolong the present period of human life to that of the antediluvians!

But in whatever estimation the merit of Paracelsus, as a chemist, may be held; certain it is, that his fame excited the envy of some, the emulation of others, and the industry of all. Those who attacked, and those who defended his principles, equally promoted the knowledge of chemistry; which, from his time, by attracting the notice of physicians, began, every where, to be systematically treated, and more generally understood.

Soon after the death of Paracelsus, which happened in the year 1541, the arts of mining and fluxing metals received great illustration from the works of Georgius Agricola, a German physician.

Lazarus Erckern (assay-master-general of the empire of Germany) followed Agricola in the same pursuit. His works were first published at Prague, in 1574, and an English translation of them, by Sir John Pettus, came out at London, in 1683. Several others have been published, chiefly in Germany, upon the same subject, since their time. Germany, indeed, has for a long time been the great school of metallurgy for the rest of Europe; and the British owe the present flourishing condition of their mines to the wise policy of Queen Elizabeth, in granting great privileges to Daniel Houghsetter, Christopher Schutz, and other Germans, whom she had invited into England, in order to instruct her subjects in the art of metallurgy.

It was in the seventeenth century that chemistry was first cultivated as a branch of philosophical science. Lord Bacon pointed out the folly and absurdity of the course adopted by the ancients, who formed theories independent of experiment and observation, and of the irregular and unsystematic empiricism of the alchemists. He shewed that in order to

know the secrets of nature, we must consult nature herself, and that it was only by a series of observations and experiments, and careful comparison of the results, that we could hope to arrive at useful knowledge. It was no small benefit to the world to have pointed out the true road to improvement, and after Lord Bacon arose, many philosophers prosecuted with ardour the course he indicated. The Hon. Robert Boyle was born on the same day that Lord Bacon died. Possessed of an ample fortune, and of the desire to improve human knowledge, he applied himself with diligence to philosophical studies, and made such progress and such discoveries as have secured to his name an honourable place amongst the promoters of science. His attainments were highly esteemed by Sir Isaac Newton. Chemistry and Natural Philosophy were the objects of his researches.

The establishment of the Royal Society in 1662 was of importance in the promotion of chemical science. This was a focus to which the discoveries of different men might be brought, and the mutual society of men engaged in similar pursuits, stimulated to make more arduous efforts to promote knowledge. Mr. Boyle was chosen President of the Royal Society in the year 1680, but objecting to the oaths required on the occasion, as unnecessary and inexpedient, he never ascended the chair.

Robert Hooke, a contemporary of Mr. Boyle, is pre-eminent as among the founders of chemical science. By his researches he contributed much to extend the knowledge possessed of numerous chemical bodies, and was able to give explanations of chemical phenomena, which still appear creditable after all the advances of modern science. His theory of combustion is particularly entitled to notice, and the following extracts, from his Micrographia, will illustrate his views.

"From the experiment of charring of coals, whereby we see, that notwithstanding the great heat and duration of it, the solid parts of the wood remain, whilst they are preserved from the free access of the air, undissipated, we may learn that which has not, that I know of, been published or hinted, nay not so much as thought of by any, and that in short is this:

"First. That the air in which we live, move, breathe, and which encompasses very many, and cherishes most bodies it encompasses; that this air is the menstruum or universal dissolvent of all sulphureous bodies.

"Secondly. That this action performs not till the body be first sufficiently heated, as we find requisite also to the dissolution of many other bodies by several other menstruums.

"Thirdly. That this action of dissolution produces or generates a very great heat, and that which we call fire; and this is common also to many dissolutions of other bodies made by menstruums, of which I could give multitudes of instances.

"Fourthly. That this action is performed with so great violence, and does so minutely act, and rapidly agitate the smallest parts of the combustible matter, that it produces in the diaphanous medium of the air, the action, or pulse of light.

"Fifthly. That the dissolution of sulphureous bodies is made by a substance inherent and mixt with the air, and is like, if not the very same, with that which is fixt in saltpetre, which by multitudes of experiments that may be made with saltpetre, will, I think most evidently be demonstrated."

These views and their applications he has farther extended in a work published in 1677, called the Lampas, and he has offered suggestions respecting the nature of flame, which are highly creditable to the acumen of his genius.

Fire was regarded by all the earlier chemists, as a principle resident in all forms of matter, and capable, under certain circumstances, of being separated and rendered evident. This notion was first combated by John Rey, a physician, of Perigord, in France. In 1629, Brun, an apothecary, of Bergerac, having melted two pounds six ounces of tin, found the whole was converted into a calx, weighing seven ounces more than the tin employed. This fact was decidedly at variance with the opinion of fire being separated by the melting. On this he consulted Rey, who in 1630 published a tract on the subject, in which he shews that the increase of weight was to be attributed to the absorption and solidification of air; which was the true explanation of the phenomenon

In 1674, John Mayow's tracts were published at Oxford. In these, he adopts the views previously divulged by Hooke, but extends and embellishes them. He contends that there exists in the atmosphere a spirit necessary to life and fire, identical with that pent up in saltpetre; that when metals are burnt they absorb it, and hence arises the increase of their weight. He maintains that nitric acid effects also a similar change; that the same principle is that which produces acids;

and is concerned in converting sulphur into an acid, that it is necessary for the respiration of animals, the vegetation of plants, and for combustion. These ideas of Mayow's clearly point out the properties of oxygen gas, as ascertained by the researches of modern science, and are honourable anticipations of what recent discoveries have been able clearly to prove and illustrate.

The discovery of the thermometer by Santorio, of Padua, furnished chemists with an instrument of the utmost importance in their researches. This philosopher was born at Capo d'Istria in 1561, and died at Venice in 1636. This instrument was much improved by the Academicians del Cimenti, who associated first in 1561, under the patronage of the Grand Duke of Tuscany. These experimentalists added several important facts to the stock of scientific information; amongst other things, the knowledge of the expansion of water previous to its freezing, and although not the first discoverers, they had the merit of calling the attention of men of science to a very curious phenomenon, which at first view appears to be a reflection of cold. (See Article CALORIC.)

Our illustrious countryman, Newton, in addition to his most important discoveries in Natural Philosophy and Astronomy, also rendered essential service to Chemistry, by his improvements of the thermometer. By shewing how to graduate different thermometers, so as to render them correspondent one to another, he enabled philosophers to record the result of their observations in such a manner as to be intelligible.

Whilst in this country Chemistry was zealously studied, it was no less so on the Continent. In 1666, the Royal Academy of Sciences was instituted at Paris, under the protection of Louis XIV. Amongst those whose contributions enrich its annals, we are particularly indebted to Homberg, Geoffroy, and the two Lemerys.

Homberg was a most active and zealous experimentalist, and met with much success. He discovered the boracic acid, which he prepared under the name of sedative salt. He was also the discoverer of the pyrophorus.

Geoffroy deserves much praise from his application of chemical science to the benefit of mankind, in preparing of medicines He is said to have been the first compiler of the Paris Pharmacopœia.

The elder Lemery had the merit of liberating Chemistry from the mystrey in which it was involved by the technical

phrases and language, in which its doctrines were expressed by its professional cultivators. In his public lectures he explained its doctrines in language intelligible to ordinary men, and made those things appear easy and simple, which when wrapt up in dark and artificially perplexed terms, seem incomprehensible.

Beccher, who was born at Spires, in Germany, in 1625, added considerably to the knowledge of natural bodies. He greatly improved the instruments used in the chemical laboratory, and much simplified many of the necessary operations, by which he much facilitated the researches of future chemists. He spent much of his time in visiting mines, and in examining mineral bodies.

As a practical chemist, his merits are very great; but in his writings, the theories by which he endeavours to explain the phenomena of nature, and the results of his experiments are very much involved in mystery, and where they can be understood, they appear to be contradictory, and untrue. He supposed that there were five elementary substances, water, air, and a vitrifiable, an inflammable, and a mercurial earth; he supposed acids to be derived from the union of earth and water; and stones to be the result of the combinations of two kinds of earths; and metals the result of the union of the three kinds of earths in various proportions. These are dreams and delusions, but do not take from the merit of his discoveries as a practical chemist.

Stahl, the Prussian, followed the footsteps of the illustrious Beccher. It was the opinon of these two philosophers, that fire enters into the composition of all inflammable bodies, and into metals, and most minerals; and in that condensed state it was called phlogiston, (latent fire,) to distinguish it from fire in its free state. They tell us that fire (phlogiston) is actually a material body, and liable to be modified by the influence of circumstances. In bodies liable to burn, it exists in a latent state; place them in circumstances in which combustion is produced, you then will behold it, perceive it operate, and feel its influence.

Van Helmont was accounted a magician, and was tortured by the Inquisition! He first gave the name of *gas* to those vapours which resemble the air we breathe; and he illustrated his theory by some phenomena of the animal economy, such as the suffocation of workmen in mines, the accidents occasioned by the vapour of charcoal, and that destructive atmos-

phere which is breathed in cellars where liquors are in a state of fermentation. He accounts for several diseases upon this principle; and ascribes the propagation of epidemical disorders to noxious vapours with which the air is infected.

The progress of useful chemistry was, however, much impeded about this period, in consequence of its cultivators being, to a great extent, physicians; who fondly hoped that this science was to furnish the means of explaining all the functions of the human body, as well as to account for the origin of disease and the operations of medicines. These notions had originated with Paracelsus, and were soon favoured by Du Chesne, Mayerne, Mynsicht, and De la Boe. The human body, according to the last named physician, was a chemical apparatus, where the heart is excited to action by the fermentation of the blood. From the food, digested in the stomach, there arise vapours distilled into the brain, which sends spirits to all the other organs of the body. Diseases depend on fermentations which corrupt the humours. From the fluids, in a state of effervescence, precipitations, dissolutions, and despumations take place, similar to those in a barrel of wine Our great Mayow, even, who had some glimpse of modern discoveries respecting oxygen gas, supposed that the inflammable particles of the air insinuated themselves into the blood, and produced a sort of vital combustion with the sulphureous elements of that fluid. Willis framed a physiological hypothesis, in which he supposed that a continual extrication of igneous vital spirits was going on in the brain :—the blood he considered to ferment like beer; spasms, he thought, arose from an explosion of salt and sulphur in the animal spirit; and scurvy, from a state of the blood similar to faded musty wine. It seems, that, in this instance, as well as in every other branch of philosophy, the human mind must run through all the devious tracks in the labyrinth of error, before it could decompose the truth.

Many men, however, rose up towards the termination of the 17th century, who made a multitude of discoveries in chemistry that tended, in a remarkable degree, to the improvement of several useful arts.

Lemery's very accurate course of practical chemistry, appeared in 1675. Glauber's works had been published at different times, from 1651 to 1661, when his tract, entitled Philosophical Furnaces, came out at Amsterdam. Kunckel died in Sweden, in 1702; he had practised chemistry for

above 50 years. Having had the superintendency of several glass-houses, he had an excellent opportunity of making many experiments in that way; and enamellers, and makers of artificial gems, say that they can depend more on the processes and observations of Kunckel, than upon those of any other author upon the same subjects.

Hermann Boerhaave, a learned physician of the University of Leyden, deserves to be noticed as a promoter of chemical science. He was a native of that city, being born in 1668, and died in 1738. Although not pre-eminently successful as an experimentalist in making new discoveries, his works were particularly excellent for clearly and eloquently explaining the whole of the chemical knowledge possessed by the world in his day.

Dr. Stephen Hales was a most diligent and acute observer of nature, and he deserves as well for the ingenuity of his experiments, and his apparatus, as for the soundness of his conclusions. He particularly directed his attention to the physiology of vegetables, and the analysis of the air, and he may justly be considered as having prepared the way for those brilliant discoveries which were soon about to be made.

The next great discoverer in the science of chemistry, and who outstripped most of his predecessors, was Dr. Joseph Black, of the University of Edinburgh. If we consider the immediate importance of the discoveries themselves, or their influence on other branches of chemistry, they may be considered as forming an æra in the science. His attention was first directed to the change produced upon chalk by the action of fire. Chalk is an insipid body, but when heated in the fire, and made red hot, it is changed into quicklime, which is highly acrid and caustic, the cause of this change was, before this time, usually supposed to be the absorption of fire; but Dr. Black ascertained that the weight of the chalk was greatly diminished; and that, therefore, the chalk instead of having gained an addition of new matter, must have parted with what it formerly had. This led to the discovery of a peculiar aeriform fluid, which is combined with chalk in its ordinary state, but which is driven off by heat, and thus denominated fixed air, and it is that which is now usually termed carbonic acid gas. He ascertained that the same aeriform body combined with magnesia, or with soda, or potash, rendered them mild; but when it was driven off by

heat they also became acrid and caustic. Dr. Black also directed his attention to the subject of heat. He had observed, that when snow was melting, although the temperature of the air might for several days be much above the freezing point, and although it be so in pools in which there was no ice or snow, yet that where the ice or snow was melting the thermometer never indicated more than 32°. This led to the hypothesis of latent heat, which we have explained under the article CALORIC; and he made numerous other discoveries of the effects of steam, and of the effects in general which are produced by the conversion of liquors into solids, of solids into liquids, and liquids into aeriform bodies. These also are noticed in the same article.

The phenomena of fixed air, now called carbonic acid gas, were examined by Dr. Macbride of Dublin, a chemist, to whom society is indebted for improvements in the art of tanning. He verified and farther illustrated all the views of Dr. Black. In 1765, Dr. Brownrigg communicated important information to the Royal Society on the same subject. He remarks that a more intimate acquaintance with those noxious airs in mines, called damps, might lead to a discovery of that subtle principle of mineral waters, known by the name of their spirit; that the mephitic exhalations, termed choak damp, he had found to be a fluid permanently elastic: and that from various experiments he had reason to conclude that it entered the waters of Pyrmont, Spa, and others, imparting to them that pungent taste whence they are called acidulæ, and likewise that volatile principle on which their virtue chiefly depends. In 1769, Mr. Lane called the attention of the scientific world to the fact, that iron is dissolved in water impregnated with fixed air. These were highly important discoveries respecting this gas, and led the way to the researches of other philosophers.

A new substance also of gaseous nature when free, but also usually found in a fixed state, combined with other bodies, was discovered by Dr. Rutherford, in 1772. This was nitrogen. He had found that when animals were confined in a portion of atmospheric air, they produced fixed or mephitic air, and this being removed by a caustic alkaline solution, he found the remainder to consist of an air which extinguished flame, and destroyed life, though it did not, like carbonic acid gas, occasion a precipitate in lime water.

Dr. Priestley now began to take the lead in scientific research.

In 1768, his attention was drawn to Pneumatic chemistry, in consequence of residing near a brewery, in which he used to amuse himself with experiments on the fixed air produced by fermentation. When he removed from that neighbourhood, he was obliged to make the fixed air for himself, and one experiment led to another, until he had contrived a convenient apparatus of the cheapest kind.

Dr. Priestley's first publication was in 1772, when he explained the mode of impregnating water with carbonic acid gas; and in 1773, his "Observations on different kinds of Air," were read before the Royal Society. This paper is full of new facts, and in particular he treats of the influence of growing vegetables on the purity of the atmosphere. In 1773, the Council of the Royal Society presented him with Sir Godfrey Copley's medal. Dr. Priestley's grand discovery, which alone would be sufficient to immortalize his name, was that of oxygen gas, which he procured from red precipitate and red lead. Besides oxygen, he discovered several other gases; and was the first who collected ammonia, and sulphurous and muriatic acid, over quicksilver.

What is particularly remarkable in the character of Priestley, and which, from its intimate relation to the improvement of science, must be here noticed, is the extreme modesty with which he always spoke of his discoveries, and, as it indeed seemed, the surprise with which he himself regarded the importance attributed to their results. Others have carefully concealed the agency of chance in their acquirements; Priestley seems to have wished to attribute every thing to it. He remarks, with singular candour, how often he had thus been favoured without perceiving it, how many times he possessed new substances without distinguishing them: and he never dissimulates the erroneous views which sometimes directed him, and which he only recognised by experience. His great chemical work is, indeed, not a series of theorems, deduced one from the other; it is a simple record of his thoughts in all the disorder of their succession.

In 1779, Bergman, a Swedish chemist, published his Opuscula. He applied himself to analytical chemistry with great success; and his superior mind, rising above theories and hypotheses, readily embraced truth as disclosed by researches, whether in accordance or opposition to preconceived opinions. M. Scheele still further extended the

boundaries of science. He was the discoverer of baryta; also of the method of obtaining citric and tartaric acids, and of chlorine; of the existence of nitrogen in ammonia. In his essays on Prussian blue, on milk, on the acid matter of fruits, and on ether, he has shewn great skill as an analyst, and great invention as an experimental chemist. He obtained oxygen and nitrogen independent of any knowledge of the prior discoveries of Priestley and Rutherford.

The next highly important discovery, was that of the properties of hydrogen, and the composition of water, by Cavendish. This philosopher, who, from the time when he commenced his scientific career, is said to have never wasted a minute of his life, or even uttered an unnecessary word, had, as early as the year 1766, and previously to the more minute and accurate discoveries of Priestley, sustained, in a paper read to the Royal Society, the following propositions: *The air is not an element; there exist several species of airs essentially different*; in which he shewed the chief properties and qualities of what was then called *fixed air*. His memoirs may, indeed, be considered as the basis of the researches of Priestley. After this, the next very important discovery of Cavendish was that of the composition of the nitric acid, of which chemists had previously had only some vague conceptions. It was at this time that Berthollet was making his discoveries of the composition of ammonia, shewing it to be formed of hydrogen and azote. The whole of the discoveries of Cavendish are described in a few pages, but we must not measure their importance by the space their history occupies.

Contemporary with Priestley, flourished that illustrious votary of chemical science — the ill-fated Lavoisier, who reformed the chemical nomenclature, which before that time was in a most confused state. His chief discoveries and contributions to the science of chemistry, consist in his proving that what had been called *fixed air*, consists of oxygen and carbon; and by demonstrating the similarity of the results of the combustion of the diamond and charcoal, he showed the probability of the identity of those two apparently dissimilar bodies. He ascertained the exact proportion of the constituents of the atmosphere, and he was the founder of the theories of combustion and of acidity, which were generally adopted until some later discoveries showed their insufficiency and partial incorrectness.

Fourcroy also lived at the same period, and though the high reputation which this chemist attained, depended chiefly on his brilliant talents as a public lecturer, he must also be mentioned amongst the discoverers of interesting facts in this science. Cavendish had shewn, that the combustion of hydrogen gas produced water; but the water obtained by his process was always more or less mingled with nitric acid, which furnished the opposers of the theory of Cavendish, with an objection that they thought decisive. Fourcroy obtained pure water, by operating in a slower manner, and he shewed that the acid resulted from some particles of azote, (always mingled with the oxygen,) which burns with the hydrogen, when the combustion is too rapid. He also discovered several compounds which detonate by simple percussion, all of which are composed of oxygenated muriatic acid, (according to the older nomenclature,) and some combustible body.

Profiting by the discoveries of Priestley, in respect to the gases, Fourcroy was enabled to give new precision and exactness to the analysis of mineral waters. He was engaged in experiments with platinum, at the same time with Mr. Tennant and Dr. Wollaston, and made some discoveries which were common to them. He was especially skilful in the analysis of metals, and when the property of the churches in France, was destroyed at the Revolution, he shewed how the copper of the bells might be separated from the tin; and thus, an alloy of use only for the specific purpose to which it had been applied, was rendered profitable to artizans. He was also the founder of the modern and improved mode of analysing vegetable substances, and was one of the first who discovered in them the existence of albumen; and pointed out how useful chemistry might be to politicians, by shewing the relative nutritive properties of different vegetables. His application of chemical analysis to animal matters, was not less exact and important, by the results to which it conducted; this was especially the case in regard to the more accurate knowledge of the composition of urinary calculi. One of the most curious facts which he discovered, was presented to him in 1786, at the burial-ground *des Innocens*, at Paris. The French government having resolved to suppress this source of infection, which, for many ages, received the bodies from the most closely peopled part of the capital, ordered, not only that no burials should hence-

forth be made there, but that the bodies already deposited there, should be transferred elsewhere. On proceeding to effect this removal, a great part of the bodies was found transformed into a white, fatty, and combustible substance, similar, in its essential properties, to *spermaceti*. A thorough investigation of the circumstances, and the comparison of some analogous facts, shewed that this change takes place in all animal matters, preserved from the contact of the air, in damp places. This discovery has already been taken advantage of, by artificially converting animal matters not adapted for food, into a substance fit for excellent candles.

At a somewhat later period flourished Morveau, the great purifier of hospitals, ships, and prisons; Chaptal, the promoter and the historian of the arts in France; Tennant, the discoverer of the true nature of diamond; Wedgewood, the inventor and manufacturer of English porcelain; Dr. Franklin, the discoverer of the identity of lightning with the electric fluid; and Dr. Watson, the friend of science, and the historian of the arts in England.

Chemistry was now in a rapidly improving condition. Throughout Britain, and the continent of Europe, this science was studied with avidity by numberless votaries, who were every day starting into existence. In France, the revolution spurred thousands on to chemical enterprise; and the energies of that nation were amply remunerated by plentiful stores of sugar from beet-root; of saltpetre from common dung-hills; by the culture of woad, and by the produce and manufacture of almost every article of luxury and necessity, with which they were formerly supplied from tropical colonies.

The French, and other chemists of the present period are so numerous, and their number is daily so much on the increase, that our limits are too small even for their names. Still we must find room for those of an Orfila, Cadet, Vauquelin, Parmentier, Berthollet, Guadet, Arago, Biot, Thenard, Caventou, and Gay Lussac, the elaborate analytical researches of every one of whom, have tended so much to the advancement of natural science. In looking towards Russia, we cannot forget the name of Kirchoff, the converter of starch and other substances into sugar; nor when turning towards Sweden, that of Berzelius, the chemical meteor of the north, who has thrown so brilliant a light over the whole hemisphere of chemistry; or to Denmark, where M. Oersted has paved the way for determining the mysterious cause of

the phenomena of magnetism. Volta, Galvani, and Morrichini, in Italy, have made discoveries which endear their names to their fellow labourers in the field of philosophy: whilst Hare, Silliman, and others, in America, have proved to Europeans, that when the tree of science is transplanted across the Atlantic, it is capable of taking as firm a root as in its native soil.

But it was reserved for the British chemist to make those researches which have tended, in the greatest degree, to promote the happiness and comfort of mankind. The energies given to the steam-engine, by Watt and Boulton, have created a great revolution in the quantity of manufactures produced, and of minerals dug from the bowels of the earth, in a given period of time. The illumination by gas-lamps, a principle invented in England, and brought into practice by Winsor, has given a new character to our streets and towns.

In enumerating the chemists of Britain we are equally limited. The names of Higgins, Henry, Murray, Thomson, Leslie, Brewster, Nicholson, Wollaston, Pepys, Children, Dalton, Kirwan, and the three Davys, are familiar to all; but it is by the truly fortunate discoveries of Sir Humphrey Davy, President of the Royal Society, that the glory of this country for science has been chiefly upheld. This philosopher's decomposition of the alkalis and earths; and his discoveries of substances new to chemists, and to the rest of the world, by means of a subscription galvanic battery, have fixed on him the admiration of the public; whilst his construction of the safety-lamp,* has thrown around him the halo of scientific philanthropy.

The establishment of the Royal Institution, and other chemical, mineralogical, and geological schools throughout Britain, has tended greatly to the diffusion of science; so much, indeed, are these institutions appreciated, that chemistry is now becoming a common branch of education. It is no longer considered merely in a medical point of view, nor restricted to some fruitless efforts upon metals; it no longer attempts to impose upon the credulity of the ignorant, nor affects to astonish the simplicity of the vulgar, by its wonders; but is content with explaining the phenomena of nature upon the principles of sound philosophy. It has shaken off the opprobium which had been thrown upon it, from the unintelligible jargon of the alchemists, by revealing all its secrets, in a language as clear and as common as the nature of its subjects and operations will admit.

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Still. A is the furnace on which the still is placed; B is the head or capital; C the refrigeratory or cooler containing the worm, and D the vessel for receiving the distilled, or condensed product. *Papin's Digester.—Retort and Receiver.* A the retort; B the tube into which the beak of the retort is introduced and joined to C the receiver 196
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THE

IMPROVED ENGLISH SYSTEM

OF

Liberal Education.

Besides the systems of mutual instruction invented and promulgated by M. M. Lancaster and Bell, and which serve for the cheap instruction of the children of the poor, another system has been invented, and generally adopted, within the last twenty years, throughout the British Empire, for the instruction of children belonging to the middling and upper classes. For the introduction and perfection of this latter system, the world is indebted to the perseverance of Sir Richard Phillips; who, in 1798, for the purpose of rendering it practical, undertook the publication of a series of Elementary Books, the plan of which is identified with his legitimate principle of conveying instruction.

He calls it the Interrogative System, and, as distinguished from the desultory and mechanical systems in general use, also confers on it the title of the Thinking, or Intellectual System. He assumes no originality of discovery, but merely claims a new and extended application of an old and recognised principle in Education. For example, ever since Arithmetic has been taught in Schools, the method has been first to develope a rule, and then require the Pupil to work Problems in subserviency to that rule. It would obviously, he says, be absurd, to pretend to perfect a young person in Arithmetic by merely directing him to commit the rules to memory, and then assuming that he had become a proficient. The more rational plan has been to require the Pupil to learn the rule, and then to exercise him on its sense and application by a variety of questions; in preparing the answers to which, he is obliged to think for himself, and to work, so to speak, in the science of which it is proposed he should acquire a practical knowledge. By these means, Arithmetic has always been taught

with success, and few persons have learned this science at School, who, in consequence of the Practical method of teaching it, are not better acquainted with its elements than with any other parts of their School learning.

The improvement, therefore, which Sir Richard Phillips has made, has been to extend the same principle to various branches of Knowledge; and, indeed, to all the subjects of liberal Education which it is customary or desirable to introduce into Schools of either sex. With this view he has produced a series of Elementary Books, by which the Pupil is enabled to work at the subject of Study, just as in Arithmetic. He has effected his purpose by means so simple and unassuming, as to create no feeling of surprise; nevertheless, they are such as completely effect the design, by a happy combination of the several parts to the end. Thus he has produced very superior TEXT-BOOKS in Natural Philosophy, History, Geography, Classical Literature, &c. &c.; and, in some cases, he has adopted standard works for TEXT-BOOKS, as the Old and New Testament, Gifford's abridgement of Blackstone, Robinson's Histories, Murray's English Grammar, &c. &c. adapting to each his own working or practical system.

The System itself consists of Miscellaneous Questions, Exercises, and Experiments, referring to different passages in the Text-Books, sometimes simple or applicable to a single fact, and at other times complicated and applicable to various facts and principles scattered throughout the Text-Book. This series of mingled questions generally extends to about five hundred in number; and the Pupil is required, as a private exercise, to furnish an answer to each question in his own phraseology. The questions are purposely mingled, and are not in the order of the Text, with a view to compel the young Student to turn over and examine every part of the Text-Book; with which, it is presumed, he must and will become familiar, long before he has answered the whole of the five hundred questions.

A thorough acquaintance with the Text-Book is, of course, simultaneously accompanied by a familiar acquaintance with the science treated of in the Text-Book; while the constant exercise of writing the answers to the questions, necessarily improves the Pupil in the important arts and practice of Spelling, Grammar, Thinking, and Composition.

But the System would be incomplete and impracticable if it ended at this stage; for the questions would often perplex the Tutor while they exercised the Pupil, and would require, on the part of the former, a more intimate knowledge of the contents and arrangement of the several Elementary Text-Books, than could reasonably be expected. The whole system, therefore, is perfected, dovetailed together, and rendered practical, by means of printed Keys, or answers, to the several sets of questions for the use and reference of the Tutor; who, by their means, is enabled to examine the answers with promptitude, and verify their correctness. These Keys, for the use and convenience of Tutors, render the System complete, and adapt the subjects and sciences to all Seminaries of Education, without creating any solicitude or trouble to the Tutor.

The same principle of requiring the Student to work at the subject of Study, has led Sir Richard Phillips to invent and publish two sets of outline Maps, and of projections of Maps, the filling up of which, by the Pupil, renders him more perfect in the details of Geography, within a few months, than he could become in as many years by the mere reading of books. As a further and very important auxiliary, with reference at once to Moral and Intellectual improvement, he has also invented two Register Books, for Schoolmasters and Governesses, by which they are enabled to record, from day to day, the conduct and improvement of every one of their pupils, and exactly balance their good and bad conduct at the end of every half year.

The facility which the new System has afforded, of teaching the various liberal sciences, has enabled schools of all descriptions to introduce them, as parts of every ordinary course of education; and thus the great mass of the English People are now initiated in branches of knowledge, the mere names of which were not understood by the same description of persons thirty years ago.

The system having become general and popular, has of course been injured in the opinions of unwary persons, by clumsy imitators, by whom, the principle and practice not being understood, their questions have been arranged in the exact order of the text; and, consequently, as the mere echoes of the text, involve no exercise of the mind, which is the sole object of the System; while quantity has been con-

sidered by these parties as a substitute for quality, and they have multiplied the questions beyond the power of the pupil to answer them in the limited time devoted to single objects of Study.

The Text-Books used in this System are indicated in the following list, and the cases are distinguished in which the questions are united in the same binding, or sold separately. The Keys may be had in a volume, or separately, as is most agreeable to the Tutor; and that no commercial difficulty may interpose or obstruct the free circulation of these works, the best allowance is made on numbers, that is usually made on Genuine Editions of School Books.

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Chemistry, as a science of experiment which developes the constitution of bodies, has for the last half century been more extensively cultivated, and more deservedly popular than any other branch of knowledge. The high estimation in which it is held may be ascribed to four causes: 1. The satisfaction which is afforded by its results. 2. Its utility in all the arts of life. 3. The fortunate discoveries of Black, Priestley, and Lavoisier, which conferred upon it a new degree of interest. And 4. The little previous preparation which an entrance on its study requires. The present may, therefore, be regarded as a chemical age. Our men of science owe their celebrity to their success in its pursuit, and the Transactions of learned Societies are chiefly occupied by its details; while the infinite varieties of nature afford a rich harvest of pleasure and discovery.

A study so general has produced a corresponding number of Authors. Besides French and German systems out of number, we have in England able, elaborate, and extensive systems by Thomson, Murray, Henry, Brande, and others; besides numerous elementary treatises, and the great assemblage of experiments by Mackenzie. The first attempt, in England, to exhibit the science in the form of a Dictionary, was by Keir, a work which, though valuable in its day, has now become obsolete. This was succeeded by the quarto Dictionary of the late ingenious Mr. William Nicholson, a compilation of inferior work, but subsequently improved in an octavo edition. The next attempt was by MM. A. and C. Aikin, and if the science were not of such fleeting character, it would never have required a successor. But that able chemist, Dr. Ure, of Glasgow, lately gave to the public a revised edition of Nicholson's octavo, and the merits of this work have been generally acknowledged.

The claims of the present work to respect and preference, are founded simply on the portability of its size, on the economy of its price, and on the care with which the latest discoveries have been incorporated, and in some degree engrafted on the labours of preceding chemical lexicographers. If the Editor has succeeded in honestly assembling the chief facts and principles recognised by the chemical world—if he has produced a volume of more convenient bulk than others, while it answers every desirable purpose of alphabetical reference—and if he has at the same time enabled the student to save his money—his objects have been attained.

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In the execution of his task the Editor has uniformly preferred facts and experiments to reasonings and theories; but he has not lost sight of the philosophy of Chemistry, or of analyses which tend to illustrate the principal phenomena of nature on all the various points to which chemical inquiry has been directed.

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